THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

NOS. DXI TO DXXII.

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NEW SERIES. DECADE V. VOL. IV.

JANUARY—DECEMBER, 1907.

LONDON:

MESSRS. DULAU & CO., 37, SOHO SQUARE, W.

1907.

HERTFORD:

PRINTED BY STEPHEN AUSTIN AND SONS, LTD.

119034
MAY 23 1908

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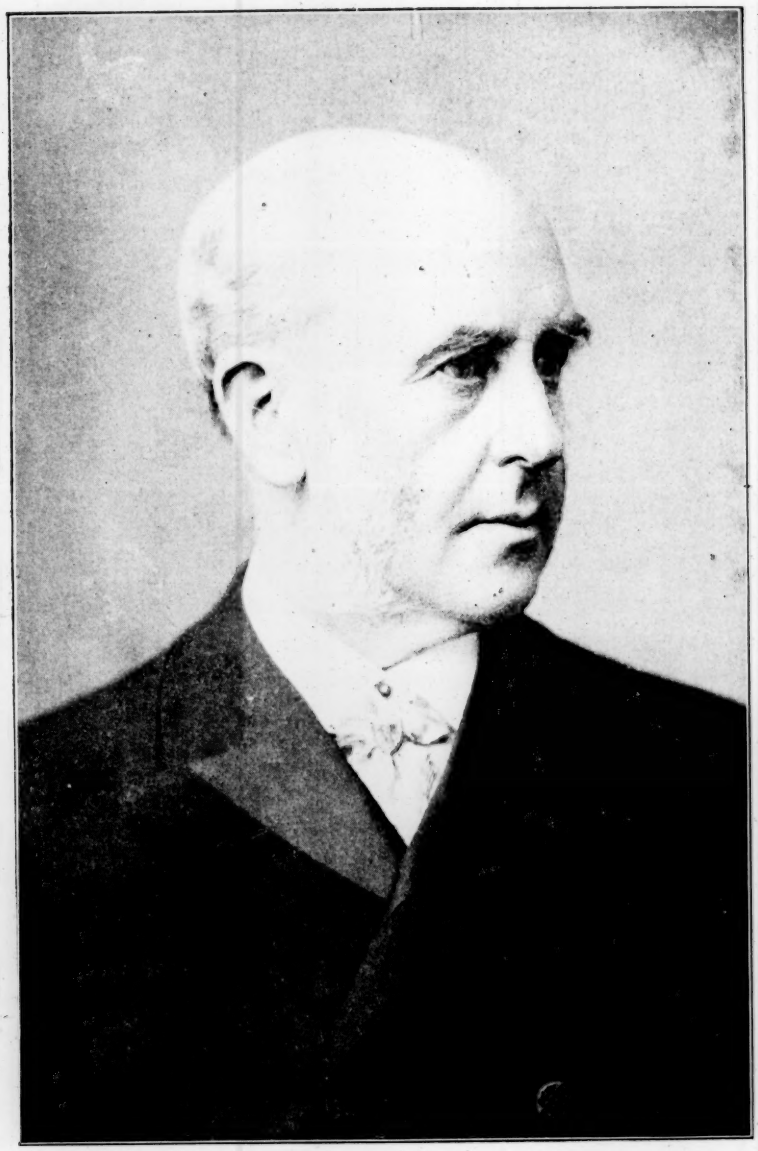
ERRATA.

p. 215, last line of right column of No. 3: *0* should be *6* (inches).

p. 308, line 15 from foot: *two last* should be *last two*. You can have but one last.—W. W.

[Mr. Buckman will feel obliged if the readers of the GEOLOGICAL MAGAZINE will kindly substitute the following corrected Memorandum for that in the September Number, p. 382.—EDIT. GEOL. MAG.]

PROCEEDINGS DORSET FIELD CLUB: DATE OF VOLUME IV.—This volume was issued without any date on the title-page; and the question has often arisen as to the correct date. Papers which it contains are dated 1883 in the Royal Society's Catalogue. However, the evidence for the date is to be found in vol. V. p. xv. An obituary notice of the Rev. H. H. Wood says: "He dies just as the 4th volume of the Proceedings . . . . . is issued to the members." He died (p. xiv) on November 3rd, 1882, so that the end of October or beginning of November, 1882, is the date of the volume in question. S. S. B.



Yours truly
A. H. Green

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. IV.

No. I.—JANUARY, 1907.

ORIGINAL ARTICLES.

I.—A Century of Geology, 1807–1907.

The Geological Society of London.

(With a portrait of its President, Sir Archibald Geikie, D.C.L., Sc.D., Sec. R.S.)[1]

WE are glad to be able to present our readers with a portrait of Sir Archibald Geikie, F.R.S.,[2] the distinguished President of the Geological Society of London, who, on account of his very large and important contributions to our science, was last year unanimously elected a second time President of the Society in anticipation of its centenary, which will take place on November 13th, 1907, he having been deemed the most fit and proper Fellow to represent the Society as its chief officer upon so important and memorable an occasion in its history.[3]

In the earlier years of his geological career Sir A. Geikie spent the major part of his time in the Highlands and Lowlands, amid the glens, lochs, and mountains of his native Scotland, and although in Murchison's and Ramsay's days he passed many of his winters in London engaged on Survey work at Jermyn Street, it was not until he was appointed Director-General of the Geological Survey of the United Kingdom and Director of the Museum of Practical Geology in 1882, offices which he held until 1901, that he became an habitué of the Geological Society and a constant figure at its meetings.

In those days (from 1855) when as a youthful geologist of 20 he commenced his official work, and afterwards (1867–82) when

[1] For permission to use the present portrait we are indebted to the President and Council of the Royal Scottish Geographical Society, Edinburgh, in whose journal it first appeared.

[2] For a brief sketch of the life of Sir A. Geikie see Geol. Mag., 1890, pp. 49–51, with a portrait; see also "Who's Who," 1907.

[3] There have been forty-three Presidents in 100 years (six of whom have been once re-elected and one twice re-elected); G. B. Greenough having served three times (1807–13, 1818–20, 1833–5); and the following twice: Buckland (1824–6, 1839–41); Murchison (1831–3, 1841–3); Sir C. Lyell (1835–7, 1849–51); Leonard Horner (1845–7, 1860–2); W. J. Hamilton (1854–6, 1864–6); and Sir A. Geikie (1890–2, 1906–8).

Director of the Geological Survey of Scotland, however remote his field of work might be, his ever-active pen and pencil kept him in touch with the world at large. "The Story of a Boulder," "Gleanings from the Notebook of a Geologist" (1858), his "Memoir of Edward Forbes" (1861), "The Scenery of Scotland viewed in connection with its Physical Geology" (1865, 3rd edition 1901), and many other of his writings[1] were read with the keenest enjoyment.

We published in February, 1890, a portrait of Sir A. Geikie and a brief summary of his work up to that date, just prior to his election for the first time as President of the Geological Society. The addresses which he gave during the two years that he occupied the chair formed the nucleus of perhaps his most important work, published in 1897 under the title of "The Ancient Volcanoes of Great Britain," two volumes, beautifully printed and illustrated. In the same year he established the "Summary of Progress of the Geological Survey," an annual publication which gives an official record of the work done by this institution. He prefaced the first number with an account of the Origin and History of the Geological Survey and Museum, a subject which he had dealt with more personally in 1895 in his "Memoir of Sir Andrew Crombie Ramsay." While still Director-General he edited in 1899 a third volume of Hutton's "Theory of the Earth," from the MS. that had long been in the possession of the Geological Society.

In 1892 he was President of the British Association at Edinburgh, and in 1899 he was chosen for a second time President of the Geological Section at the Dover meeting. In 1900 he published an official memoir on "The Geology of Central and Western Fife and Kinross." In the following year he retired from the public service; but, as we intimated (GEOL. MAG., February, 1901, p. 96), it was not his intention to lay aside either his hammer or his pen. In 1902 he brought out another Survey Memoir on "The Geology of Eastern Fife"; in 1903 he issued a fourth edition, in two volumes, of his "Text-Book of Geology," a work of 1,472 somewhat closely printed pages. From the severer side of science he turned to "Scottish Reminiscences," a volume published in 1904; and in 1905 he issued "Landscape in History and other Essays." Meanwhile, in 1903, he accepted the office of Secretary to the Royal Society in conjunction with Dr. Joseph Larmor, a position which might alone have given enough work for any man in the days of his *retirement*.

In the earlier days of the Geological Society, "the age of the demigods," but comparatively little was done by its members to interest the outside world. The Society was a *very select body*, and as one of its members observed at the time, the Council was practically

[1] For original articles by Sir A. Geikie and notices of his writings, see the GEOL. MAG., 1861, p. 22; 1865, p. 125; 1866, pp. 456, 549; 1867, pp. 171, 316, 465; 1868, p. 219; 1869, pp. 32, 129, 137; 1870, pp. 41, 136; 1871, p. 279; 1874, p. 81; 1878, pp. 49, 128; 1879, p. 278; 1882, p. 322; 1883, pp. 39, 47, 80, 258; 1888, pp. 42, 282; 1889, p. 32; 1891, p. 498; 1894, p. 188; 1895, p. 132; 1896, pp. 42, 481; 1897, pp. 233, 326, 371, 417; 1898, pp. 232, 306, 358; 1899, pp. 321, 452; 1901, p. 81; 1903, p. 273; 1904, pp. 133, 135; 1906, pp. 145, 193.

the Society, and existed to publish its own papers, other peoples' opinions and papers being a negligible quantity.

As the years passed the names of Greenough, Conybeare, Buckland, Fitton, Sedgwick, Portlock, Horner, Murchison, Lyell, De la Beche, Forbes, Phillips, and Sharpe commenced to attract attention, and the world began to take an interest in the science; the writings of Lyell especially attracted attention, and as he himself remarked at the Jubilee of the Geological Club in 1874, he had been condemned for his heresies from every pulpit in the country, but had lived to see as many parsons as laymen turn geologists.

From the Geological Society has sprung into existence the Geological Survey of the United Kingdom, with its staff of surveyors all over the country, producing annually maps and memoirs of the greatest value to our science. The Museum of Practical Geology and its Royal School of Mines soon became another living centre from which a steady output of young geologists went forth each year to conquer the earth. Nor may we forget that in addition to the Quarterly Geological Journal and the Society's Transactions has sprung into being the Palæontographical Society, with its grand array of monographs of British fossils (now 60 years old). E. Charlesworth's *London Geological Journal*, 1846–47, the *Geologist*, edited by S. J. Mackie, 1858–64, the Geological Magazine, by H. Woodward, 1864 to the present time—all these have tended to help on the science of geology.

As Englishmen we have reason to feel justly proud of our William Smith,[1] and his first Geological Map of England; of his nephew, John Phillips, whom he trained up to be the future teacher of many, the author of the "Geology of Yorkshire," the Curator of the York Museum, the home of the Yorkshire Philosophical Society, which under Harcourt gave birth to the British Association for the Advancement of Science (now 76 years of age), that has done so much to promote geology as a study in these Islands; of Buckland, Sedgwick, Lyell, Murchison, Prestwich, Jukes, and the long list of their followers who have kept alive the flame of enthusiasm on the altar of our science through a hundred years. Nor must we forget that, born of the Geological Society, the Geologists Association (already 48 years of age) has arisen as a vigorous offspring of the elder Society, and is even stronger on its feet than the parent, travelling each year over the length and breadth of the land and extending its rambles into France, Italy, and elsewhere. Never had Britishers reason to be prouder of a scientific body than we of the Geological Society (just a century old), the doyen of all the Geological Societies of the world, from whose founders and followers have arisen so many living off-shoots of working associations, publications, field clubs, and local societies. Copying the toast of a great city company we may exclaim "Long may it flourish and grow, root and branch, for ever."

[1] Styled by Sedgwick "the Father of English Geology." See Geol. Mag., 1869, pp. 356–359; 1870, pp. 301–306; 1873, p. 34; 1877, p. 378; 1892, pp. 94, 144; 1897, p. 439.

II.—A Note on Fossil Plants from the Carboniferous Limestone of Chepstow.

By E. A. Newell Arber, M.A., F.L.S., F.G.S.

THE occurrence of plant-remains in the Lower Carboniferous rocks of England is so rare that the recent discovery of impressions in beds belonging to that series at Chepstow, by my friend and pupil Mr. M. P. Price, B.A., of Trinity College, Cambridge, is worthy of record. Mr. Price has obtained several examples of a Sphenopterid frond and other plant fragments from a bed of sandy shale of about 4 feet in thickness, lying between a red sandstone below and limestone beds above, in one of the Pen Moel quarries on the left bank of the Wye, immediately to the north of Chepstow. This locality is mentioned in Dr. Vaughan's[1] recent paper on the palæontological sequence in the Carboniferous Limestone of the Bristol area. That author informs me that he refers the beds in question to the lower portion of the *Seminula*-zone (S_1 of his classification) on the evidence of the fauna.

Considering the sandy nature of the bed, the impressions are fairly well preserved. The most abundant plant is a leaf belonging to the frond-genus *Sphenopteris*, which, so far as I can judge, appears to be identical with *Sphenopteris Teiliana*, Kidston,[2] only known hitherto from the Lower Carboniferous beds of Teilia Quarry, Gwaenysgor, Flintshire. I have compared the Chepstow fossils with examples from the Flintshire beds in the Sedgwick Museum, and on the whole they agree very well. In some cases the dichotomous branching of the rachis, which is so characteristic of this fern-like plant, is clearly seen. The pinnules are indifferently preserved, but the best of them resemble fairly closely the specimens from Flintshire. The nervation is not, however, preserved; nor is it to be seen in the examples previously known.

There is also associated with one of these fronds a small fragment resembling a fructification, which recalls that figured by Mr. Kidston[3] from Flintshire as "the fructification of a fern." A stem structure possibly belonging to a fern-like plant is also represented, and shows traces of what may perhaps have been petiole-scars, but not very clearly. It recalls the appearance of a badly preserved *Megaphyton* in some respects. A branched rachis without foliage, and a small portion of an obscurely ribbed cast complete the list of specimens so far obtained.

The discovery of a new locality for *Sphenopteris Teiliana* is of interest. On the evidence of the flora from Teilia Quarry, Mr. Kidston inclined to the opinion that the Flintshire beds were the equivalents of the Calciferous Sandstone of Scotland. On the other hand, Dr. Vaughan[4] has shown that the fauna of the Chepstow deposits belongs to the higher series (Visean) of the Carboniferous Limestone

[1] Vaughan: Quart. Journ. Geol. Soc., vol. lxi (1905), p. 251.
[2] Kidston: Trans. Roy. Soc. Edinb., vol. xxxv, pt. 2, p. 424, pl. i, fig. 3, 1889.
[3] Kidston: ibid., p. 426, pl. ii, figs. 8 and 9.
[4] Vaughan: ibid., pp. 251 and 186.

Series. It is quite possible, however, that this species may occur in both the lower and upper beds of the Lower Carboniferous.

The specimens[1] discussed here have been presented to the Sedgwick Museum by Mr. Price, who informs me that he hopes to make yet further collections from the Chepstow beds. Such should prove to be of considerable interest if well-preserved impressions can be obtained.

III.—An Excursion to the Volcanoes of Nevado de Toluca and Jorullo in Mexico.[2]

By Bernard Hobson, M.Sc., F.G.S.,
Lecturer in Petrology and Geology in the Victoria University of Manchester.

(PLATE II.)

IN connection with the meeting of the Tenth International Geological Congress in the city of Mexico, an excursion, known as the Jorullo Excursion, was organised, of which the following is an account:—

Nevado de Toluca.

Under the leadership of Mr. T. Flores, geologist of the Mexican Geological Institute, a party of thirty geologists left Mexico city (altitude 7,432 feet) on August 20th for Toluca (altitude 8,761 feet), distant 46 miles by the Mexican National Railway. From a small hill close to Toluca an excellent view of the town itself and the extinct volcano of Xinantecatl or Nevado de Toluca (altitude, according to Flores, 14,973 feet), distant about 12½ miles to the south-west, is obtained. It lies at the southern edge of the great Mexican plateau (Mesa central), and has the form of an abruptly truncated cone, resembling that of Vesuvius before the eruption which destroyed Pompeii and Herculaneum. On August 21st we left Toluca by train for Calimaya, 11 miles distant and on the east side of the volcano. At Calimaya station we were met by a body of *rurales* or rural mounted police, armed with carbines, swords, and revolvers, who were to form our escort. They were holding horses for our use. We mounted, and rode at first by a gently ascending road through fields of maize and agaves (American aloes). The road then followed the bank of a barranca or stream-gully, which was dry. We dismounted to examine the excellent section exposed. The walls of the barranca were composed of well-bedded white pumiceous tuff, the lapilli varying in size from that of peas to that of a fist or larger. In one place the tuff was seen to overlie a bluish-grey bed of volcanic sand, in another the underlying bed consisted of soft black peat-like soil,

[1] Carb. Plant Coll., Nos. 1478–1484.

[2] For most of the facts in this paper I am indebted to two papers, "Le Xinantecatl ou Volcan Nevado de Toluca," par T. Flores, and "Le Jorullo," par E. Ordoñez, both forming part of the "Guide des Excursions du X^e^ Congrès Géologique International, Mexico, 1906." An excellent general map of Mexico on which the route of the excursion can be followed is the "Carte du Mexique. Dressée au dépôt de la Guerre," par Mr. Niox, scale $\frac{1}{2000000}$ = 47·34 miles to 1 inch, date 1873, price 1 franc plus postage, from H. Barrère, 21, Rue du Bac, Paris. Of railways it shows only one, but the railways up to date are shown on Rand, McNally, & Co.'s Indexed Atlas of the World, Map of Mexico, scale 72 miles to 1 inch.

but the most interesting point was the exposure in the vertical barranca-wall of a transverse section across a small stream-bed filled with pumiceous tuff differing slightly in colour and bedding-planes from the main mass, showing that water had played a part in the deposit of the almost horizontally bedded tuffs. Higher up we entered a pine forest, and climbed a shoulder whence a splendid view of the summit of the mountain and the surrounding country was obtained. After descending, with many windings, through most beautiful woods almost as much as we had ascended, we reached the Hacienda del Veladero, where we lunched. We then resumed our ascent, following the edge, crossing and then following the bottom of a deep barranca in volcanic tuff, until we reached our quarters for the night, two specially erected wooden sheds. Rising at 5 the next morning, after a somewhat sleepless night owing to the cold, we ascended through a pine forest amid wild lupines. The sun was rising, and through the beautiful foreground of pines we saw a magnificent view; the broad and flat plain to the east was filled with a sea of cloud, above which towered in the distance the snow-clad cone of Popocatepetl (17,876 feet) and the broader white summit of Ixtaccihuatl (17,518 feet). Abruptly the forest came to an end at 4,100 metres (13,448 feet), and we rode by a winding path on the treeless but grassy mountain side until we reached a cairn at one of the lowest points on the crater rim, whence we obtained a fine view of the interior of the crater with its central lava dome.[1] We rode down the interior slope of the crater to the shore of the Laguna Chica, the smaller of two lakes of crystal clear water, which is separated by the central lava dome from the Laguna Grande,[2] which is about 300 metres long by 213 broad and 10 metres in maximum depth, according to D. Joaquín Velazquez de León. The lakes lie at 4,270 metres (14,005 feet) above sea-level, hence the highest point of the crater rim, "Pico del Fraile," to which some of us climbed, rises 968 feet above their surface. The inner slopes of the crater have an average inclination of 30°, and are covered by screes to within a short distance of the rim: scattered patches of grass and wild flowers occur to a considerable height, above which are bare rock and scanty patches of snow. According to Dollfuss & Montserrat the elliptical crater measures along its major axis from north-west to south-east 1,431 metres (1,565 yards) by 595 metres (650 yards) along its minor axis. Mr. T. Flores regards the cone as built up of a series of lava-flows covered by pumiceous tuff and breccias. Some of the lava masses form prominent crags around the crater rim, but the tuffs form the main feature of the outer slopes of the cone, at any rate on the north and north-east sides. The final manifestation of volcanic energy was marked by the formation of the central lava dome. According to Mr. E. Ordóñez all the lavas are hornblendic hypersthene andesites. The evidence as to the age of the volcano cited by Mr. Flores does not appear to me quite convincing. He says that Mr. J. G. Aguilera[3]

[1] See Plate II, Fig. 2.

[2] See Plate II, Fig. 3.

[3] "Bosquejo Geologico de Mexico": Boletines del Instituto Geológico de Mexico, Nos. 4, 5, and 6, p. 229.

refers to the Upper Pliocene the pumiceous tuffs and breccias of the Las Cruces, Monte Alto, and Sierra Nevada range (separating the basin of Mexico city from the valley of Puebla), and Mr. Flores states that these tuffs correspond to those around the Nevado de Toluca, but apparently Mr. Aguilera does not give his reasons for assigning the tuffs he mentions to the Upper Pliocene. As Cretaceous limestones underlie the volcano and Pleistocene deposits overlie the argillaceous tuffs, which in turn overlie the pumiceous tuffs of the volcano, it may be considered to be of Tertiary age, and both Mr. Flores and Mr. E. Ordóñez believe it to have first appeared at the beginning of the Pliocene. No eruption is recorded as having occurred in historic times, and the mountain appears to have suffered considerable erosion. We rode down to Calimaya by a more direct path, and returned by train to Toluca the same evening.

Toluca to Jorullo.

August 23rd. We left Toluca by train for Morelia (altitude 6,396 feet), 188 miles distant, passing on the way the saline lake of Cuitzeo, 45 miles long by 10 wide, but, like the rest of the Mexican lakes, very shallow, hardly more than 20 to 26 feet deep.

August 24th was spent in Morelia, and on the 25th Mr. Ezequiel Ordóñez, sub-director of the Mexican Geological Institute and Secretary of the International Congress, who was to be our guide to Jorullo, joined us. In the afternoon we left by train for Patzcuaro (alt. 7,183 feet), 39 miles away. Close to Patzcuaro is the beautiful lake of the same name (alt. 6,690 feet), about 12½ miles long and 23 feet in average depth. We walked from the town to the terrace of Los Balcones on the volcanic hill of El Calvario. From this point there is a splendid panorama of the lake, intersected by promontories, studded with islands and surrounded by basaltic cones so numerous, so graceful, and so perfectly preserved as to rejoice the heart of the geologist.

August 26th. At 6 a.m. we started, accompanied by an escort of *rurales*, to ride to Ario, about 28 miles away. After passing through maize fields we rode through the most beautiful park-like scenery, the hills on either side being all volcanoes, often beautifully preserved cones and either wooded or grass-grown from foot to summit. Volcanoes are as plentiful in Mexico as blackberries in England. At 8.45 a.m. we arrived at Santa Clara de Portugal, where maidenhair ferns grow like weeds on the old walls. On leaving it we passed through country which one might have mistaken for a bit of the English Lake District, but no lakes were visible, and on a near view the vegetation differed. We arrived at Ario (alt. 6,200 feet) at 2.30.

August 27th. We left Ario at 6 a.m. Our road was chiefly downhill; we were descending the southern escarpment of the Mexican plateau. The vegetation became more tropical; bananas, mimosas, and Opuntias were common, and small well-wooded volcanic cones were numerous. At 9.35 we reached Rancho Nuevo (alt. 4,593 feet), 11 miles from Ario. We left at 12.40 and continued to descend, passing through a pine forest. In an hour we were among fan-palms, and as we reached lower levels they increased in number. Here and

there a Ficus had entwined its stem with that of a palm, and orchids grew among the branches. We passed the Hacienda La Playa, and descended to the bottom of the natural amphitheatre in which Jorullo lies.[1] Giant trees dropped their adventitious roots to the ground, climbing plants entwined their trunks, exquisite natural ferneries were on every hand, but what most delighted us was the abundance of streams and the greenness of the luxuriant tropical vegetation. At 5.15 p.m., after 15 miles ride from Rancho Nuevo, we reached the comfortable house at Mata de Platano, south-east of Jorullo, which the copper-mining Compañia de Inguaran had placed at our disposition.

At last we had arrived at the goal of our journey, the historic volcano, which first appeared in September, 1759, and was visited in 1803 by Alexander von Humboldt, whose description[2] has made it classic ground for the geologist.

Jorullo.

As already mentioned, Jorullo lies at the bottom of a great natural amphitheatre, 8¾ miles in diameter, formed by erosion in the Central Plateau, and with its concavity facing south. Within this amphitheatre the volcano stands upon a raised platform or minor plateau of old basaltic lavas, named the Mesa de la Higuera, the surface of which is inclined towards the south and west. On every side stand older basaltic cones, such as the Cerro Blanco, 1¼ miles to the south, Cerro del Bonete, 1 mile to the east, Cerro del Sauceito, 1½ miles north-east, Cerro de la Cruz, 2½ miles north-west, Cerro del Veladero, 2½ miles west. Looking northward from the Pico de Humboldt, the north-eastern summit of Jorullo crater rim, one sees the escarpment of the great plateau rising over 3,000 feet above the floor of the amphitheatre and densely wooded; the western side of the amphitheatre is formed by the dioritic chain of Las Canoas, the eastern by the chain of Inguarán, while towards the south rise range after range of mountains until in the far distance the great Sierra Madre del Sur closes the view. Only immediately to the west of the cone is there a comparatively level space of 3¼ square miles covered by the lava-flows of Jorullo. Rising from the plateau of Higuera, and ranged in a line running from N. 35° E. to S. 35° W. true, stand four cones, not six as older observers reported. These are the vents of Jorullo, though only the largest of the four is properly so called, the other minor (not parasitic) cones being termed 'volcancitos' or small volcanoes.

The Chief Cone.

Although the highest part of the cone (termed by Ordóñez Pico de Riaño) reaches 4,330 feet above sea-level, Jorullo is not imposing from its size, for even on the west side it only rises 1,312 feet, and on the east side only 574 feet above its base. It is hardly an exaggeration to say that there are scores of nameless volcanoes in Mexico of equal size, though not of equal interest.

[1] Humboldt mentions guavas (*Psidium pyriferum*); a fan-palm (*Corypha pumos*), now called *Cocernicia pumos*, and an alder (*Alnus Jorullensis*) at the Playas de Jorullo.

[2] "Kosmos": J. G. Cotta'sche Verlag, Stuttgart, vol. iv (1858), pp. 334–348, and English translation by Otté & Dallas, Bohn's Library, 1865, vol. v, pp. 308–323.

It is of regular conical form, its summit broadly truncated by a comparatively large crater. Its sides slope at angles varying from 28° to 35°, the higher angle being met with on its southern and western sides. It appears most symmetrical as seen from the south, on which side, more especially, its slopes are traversed by numerous narrow, deep, and straight radiating furrows or barrancas due to erosion. It is most impressive as seen from the west, as on that side its height above its base is greatest. Seen from the west the latest (No. iv) lava-flow rises as a lofty black prominent and very conspicuous ridge forming an unsymmetrical appendage on the north side of the cone. (See Plate I, Fig. 1.)

To resume the account of our visit. August 28th. In the early morning we walked down the hill at Mata de Platano, crossed the stream at its foot, and followed a dry stream bed, in well-stratified black lapilli of Jorullo, to the east side of the cone, where the ascent proper began. The outer slope of the cone is composed of completely incoherent black lapilli mostly about the size of peas. In this soil grows from foot to summit of the cone a dense tropical vegetation of mimosas or acacias and other trees (reaching 15 or 20 feet in height), shrubs, grass, and maidenhair ferns. The grass does not form a continuous covering, but everywhere the lapilli are exposed, and nothing essential appears to be concealed, so that the luxuriant flora can hardly be considered a drawback by the geologist, while it greatly adds to the attractiveness of the ascent. We were half-way up the cone when a tropical downpour of rain began and lasted half an hour. The sky cleared and we soon reached the north-eastern summit of the crater rim which Mr. E. Ordóñez has christened Pico de Humboldt. From this point there is a splendid view of both the immediate neighbourhood and the more distant country.

The Crater.

The first feature to arrest our attention was the crater. It is ovoid in form, and measures along its major axis from north to south 568 yards by 421 yards from east to west, and its depth from the highest part of the rim is 489 feet. A breach 500 feet wide and about 200 feet deep has been formed on the northern side by the last outflow of lava. While the exterior of the cone consists of lapilli and agglomerate the interior of the crater forms an inverted conical cavity coated with lava weathered to a reddish brown and almost bare of vegetation. A series of curved fissures formed by the contraction of the lava in cooling has allowed the inner lava lining of the crater to sink in a series of terraces bounded by steep or vertical walls. The rim of the crater is a mass of very scoriaceous rough lava, very difficult to walk over, and in places very narrow. We made our way, however, along it to the west side of the rim, whence a bird's-eye view of the lava streams is obtained.

The Lava-Streams and Fumaroles.

Ordóñez[1] gives an excellent geological map, scale $\frac{1}{50000}$ or 2·11 inches to 1 mile, of the Jorullo volcanoes (from which,

[1] Loc. cit.

curiously enough, all the watercourses are omitted). According to his map and description Jorullo gave rise to four lava-streams, which Ordóñez calls 'malpays,' literally 'bad lands.' The first and oldest of these was the most extensive, and each succeeding one was of less extent. The first flow was the first feature to be formed after the opening of the vent or vents, and like the second flow probably issued from the western foot of the Higuera plateau. It covered an area about 3,280 yards long by 3,060 yards broad, or approximately 3¼ square miles. The second flow covered a little more than half the area of the first, and in most places overlies its predecessor. The margin of the second flow forms a kind of wall 130 to 160 feet high. Ordóñez holds that not until these two flows had taken place did the vents enter on an explosive phase and form the four cones which we now see. The last two of the four lava-flows took place exclusively from the main cone of Jorullo itself by the breach already mentioned. Looking down upon lava-stream No. iii from the summit of the cone, we could clearly distinguish its margins and its black surface, and even trace the curves of flow of its surface, their convexity facing down-stream and outlined by green lines of vegetation growing on it. The fourth and last of the lava-streams is so fresh and devoid of vegetation that I think personally it must be much later in date than the first. Its surface is not ropy, but exceedingly rough, scoriaceous, and of the 'aa' type of the Hawaiian volcanoes. Just outside the crater, the upper surface of the stream having solidified, while the still liquid lava within flowed on, a tunnel was formed in the lava, the roof of which ultimately collapsed and left a channel full of débris about 1,640 yards long, about 230 to 330 feet wide, with walls 16 to 33 feet high. This is called the "Calle de las Ruinas" or "Street of Ruins."

As already mentioned the latest lava-stream forms a prominent ridge, and its sides, far from lying in or accommodating themselves to a pre-existing valley, rise with almost wall-like precipitous steepness from the surface of the cone. Another noteworthy point, well shown on the map of Ordóñez, is the fact that all the lava-streams have flowed to the west or north and not to the east (except a portion of the latest stream). This westerly flow is due to the westward slope of the plateau of Higuera. Several fumaroles, which at present give off only steam at a temperature of 75° C., occur in the crater and on the latest lava-flow, and Ordóñez found a temperature of 165° C. at a depth of 1 metre in a fumarole on the last lava flow.

The Volcancitos and Volcanic Bombs.

From the crater rim of Jorullo the volcancitos are well seen. Like the main cone, the volcancitos are composed of lapilli from the size of a nut to that of a fist, and like it too are clothed with verdure from base to summit. The Volcancito del Norte is about 1,500 yards north-east of the main cone, rises to 3,903 feet, or 377 feet above its eastern base (the plateau of Higuera); the Volcancito de Enmedio (middle cone) lies about 1,500 yards south-west of the main cone, rises to 3,411 feet, or 180 feet above its eastern base; while the Volcancito del Sur (southern cone), about a mile

south-west of the main cone, rises to 3,592 feet or 394 feet above its base. In all three cases the western base is 180 feet lower than the eastern. Between the main cone and the Volcancito de Enmedio are several mounds of volcanic sand and lapilli, which have been regarded by previous observers as additional cones, but which, according to Ordóñez, show horizontal bedding-planes and not the structure characteristic of cones of eruption. The outer slopes of the volcancitos are as steep as those of the main cone, reaching as much as 35°. All three volcancitos are horse-shoe shaped, being breached on their western side. Mr. Ordóñez gives an explanation of this breaching which I find it difficult to accept. He says:[1] "En effet, ces cônes, peu élevés et d'un volume relativement faible, reposaient sur la lave, alors incomplètement solidifiée; et celle-ci dans son mouvement lent de descente, entraina avec elle, la partie de ces édifices, qui avait pour base cet instable piedestal, et leurs pans détachés, perdirent l'équilibre et se réduisirent en morceaux." I should have thought it more probable that each was breached in the ordinary way by an outflowing lava-stream, but Mr. Ordóñez maintained that such was not the case, and time did not permit me to settle the question by an adequate examination of the ground.

The volcancitos are characterised by the abundance of volcanic bombs, which occur in their cones and appear to be absent from, or scarce in, Jorullo proper. These bombs are spherical, ellipsoidal, or fusiform, and sometimes show the fractured concentric layers known as bread-crust structure. They are mostly as big as a man's head, but may reach a cubic metre in size. On our way back from Jorullo to Mata de Platano on August 28th, we saw many excellent examples of them in the southern slopes of the Volcancito del Sur. On August 29th we left Mata de Platano and walked along the eastern foot of Jorullo, and then turned westwards along the southern side of the Volcancito del Norte and the northern edge of the latest lava-stream of Jorullo, afterwards crossing flows Nos. iii, ii, and i, which are more or less covered with vegetation which is not dense, the trees occurring scattered as in a park.

The Hornitos.

We examined several 'hornitos' (literally 'little ovens'). These are circular or elliptical mounds, generally perhaps 10 to 15 feet long and 3 to 5 feet high, consisting externally of numerous layers of incoherent small black lapilli or volcanic sand, each layer from one-fifth of an inch to 2 inches in thickness, arranged concentrically and parallel to the outer surface, forming domes with quâ-quâ-versal dip of the layers. Most of the hornitos have an opening through which gases and vapour formerly escaped, and they all contain a solid or hollow nucleus of the underlying basaltic lava.[2] They are simply surface vapour vents of the lava-streams coated with layers of volcanic sand and lapilli which, occurring in thick accumulations near the four cones, overspread the older lava-streams of Jorullo, but not the latest, which hence appears to be the result of the final effort of the volcano.

[1] Loc. cit., p. 36.

[2] For details see the paper by Ordóñez already mentioned.

The hornitos do not agree with Humboldt's description, part of which is as follows; "Each of the numerous Hornitos consists of weathered balls of basalt, with pieces separated in concentric shells; I could often count 24 to 28 such shells. The balls are somewhat spheroidally flattened, and are mostly 15 to 18 inches in diameter; but also vary from 1 to 3 feet . . . . ."[1] The soft mass of clay which unites the balls is, strangely enough, divided into curved lamellæ, which wind about through all the interstices of the balls." In this description Humboldt appears to have been in error.

Petrography.

As to the petrographical nature of the lavas of Jorullo, according to Ordóñez they are olivine basalts, and there is no appreciable difference between the successive lava-streams. Specimens collected by me from the top of the main crater rim, the surface of the termination of lava-stream No. iv, and the lapilli of the main cone agree in essentials.

Phenocrysts. Olivine is present in all cases; augite, almost colourless in thin section, is less common; plagioclase (contrary to Mr. Ordóñez's observation "une première génération de feldspath manque presque complètement") occurs in numerous small phenocrysts (except in the lapilli). Brown hornblende crystals, with a dark resorption border, occur like phenocrysts (but may be inclusions). It was absent from the lapilli.

The groundmass makes up the bulk of the rock, and consists of small but idiomorphic crystals, viz., felspar laths, augite crystals, olivine, often reddish brown, and specks of black iron ore, all embedded in a brownish globulitic glass filling the interstices between the felspar laths and most abundant in the lapilli.

The older basalts of the plateau of Higuera and the older volcanic cones are distinguished from those of Jorullo by the presence in them of nepheline and hypersthene.

After examining the hornitos on August 29th we made our way to the Hacienda La Playa, whence we rode to Arlo, and on the 30th to Patzcuaro, which we left on the 31st by train for Mexico, arriving there at 6.30 a.m. on September 1st.

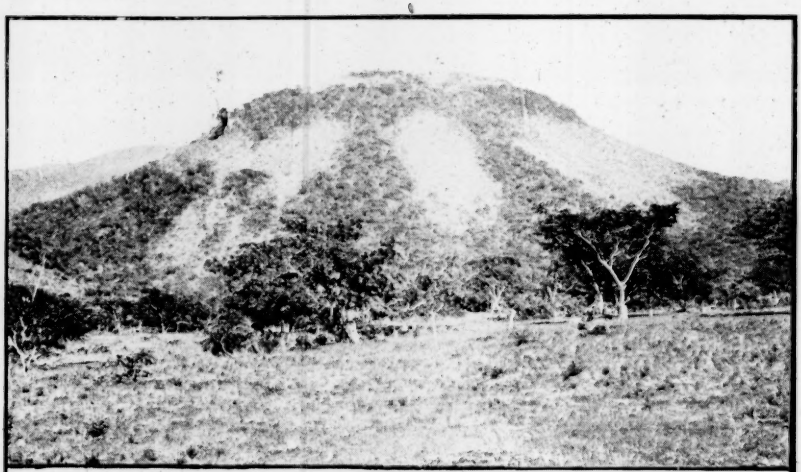
Humboldt's Craters of Elevation.

Humboldt[2] considered Jorullo an example of one of Von Buch's craters of elevation due to the swelling up of a pre-existing surface. Of this there is not the slightest evidence. Mr. Ordóñez[3] thinks the eye-witnesses of the welling up of the earlier lava-streams of Jorullo were misled by them into thinking that the ground had risen in swellings.

The possible existence of a Line of Fissure.

Mr. Ordóñez, while not rejecting *a priori*[4] the hypothesis that the four cones of the Jorullo group are on a line of fissure, does not favour

[1] I translate from the German edition of "Kosmos," vol. iv, pp. 340, 341 (J. G. Cotta'scher Verlag, Stuttgart, 1858); English version (Bohn's, 1865), vol. v, p. 317.
[2] "Kosmos," vol. iv, pp. 340, 336.
[3] Loc. cit., p. 42.
[4] Loc. cit., p. 22.



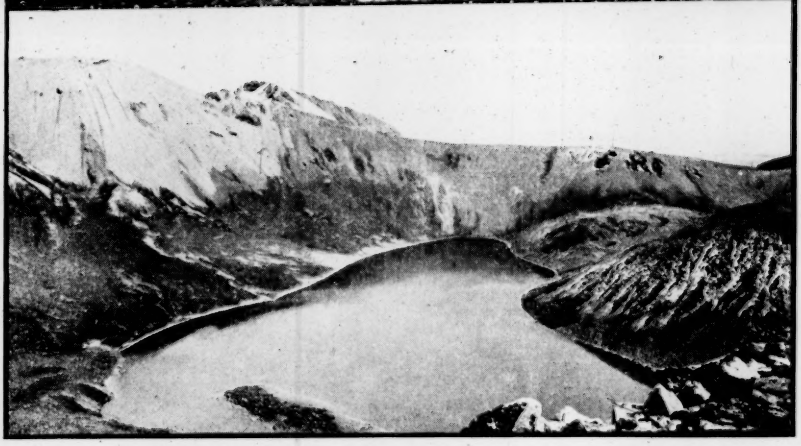


FIG. 1. Jorullo from the west. FIG. 2. Crater of Nevado de Toluca.
FIG. 3. Laguna Grande in crater of Nevado de Toluca.

it. He says:[1] "A peine le sable volcanique est-il emporté de quelque endroit immédiatement voisin des cônes que déjà, le basalte ancien des plateaux apparait, dans sa position primitive, sans avoir éprouvé, par suite des éruptions le moindre déplacement. C'est pour cela que nous croyons que les cônes se sont formés autour de petits tubes, ou cheminées, et non sur une fracture continue." With regard to the No. i lava-stream he says:[2] "L'observation du terrain semble établir que, dans la formation du malpays le plus étendu et le plus ancien, ont participé des laves qui sortaient simultanément des quatre bouches et qui, dans leur course, se sont fondues au point de ne plus constituer qu'un seul gâteau."

With all deference to Mr. Ordóñez I venture to tentatively suggest the following hypothesis. We may have here a most interesting example of the transition from fissure eruptions to crater eruptions. The lava-streams Nos. i and ii, each of which, as I understand him, cannot be separated into portions according to the vents which gave rise to them, may well have both issued from a fissure. This fissure being partially obstructed may then have retained four openings through which the fragmental materials of the four cones were ejected. Finally, the vent of the main cone alone remained open and gave rise to the last two lava-streams.

EXPLANATION OF PLATE II.

DESCRIPTION OF PHOTOGRAPHS.

Fig. 1, Jorullo. Figs. 2 and 3, Nevado de Toluca.

FIG. 1.—View of Jorullo from the magnetic west, showing its wooded slopes, the latest, No. iv. lava-stream issuing from the cone high up on the left, and in the foreground the park-like vegetation on the No. ii lava-stream.

FIG. 2.—View of the crater of Nevado de Toluca. The bridle-path leading down into the crater on the right, a part of the Laguna Chica with the central lava dome immediately behind it, and behind the dome the interior slopes covered with screes; and on the left the Pico del Fraile, or highest point of the crater rim.

FIG. 3.—View of the crater of Nevado de Toluca looking N.E. from high up on the S.W. crater rim. In the centre the Laguna Grande with the lava dome on the right, and in the right foreground part of a scree with patches of snow.

IV.—PIPE-AMYGDALOIDS.

By A. L. DU TOIT, B.A., F.G.S., Geological Survey of Cape Colony.[3]

PIPE-AMYGDALOIDS, although recorded in the Deccan Traps of India and in Tertiary Basalts from Mull, are rather uncommon rocks except in South Africa. They were described by Professor E. Cohen,[4] who obtained his specimens through Mr. J. Orpen from the Stormberg lavas (Lower Jurassic) of Basutoland, a formation in which they are very abundant. Since then they have been found

[1] Loc. cit., p. 23.
[2] Loc. cit., p. 41.
[3] With the permission of the Geological Commission.
[4] Cohen, "Ueber einige eigenthümliche Melaphyr-Mandelsteine aus Süd-Afrika": Neues Jahrbuch, 1875, p. 113. "Mandelstein aus den Maluti-Bergen, Süd-Afrika": ibid., 1880, pp. 1, 96.

in other volcanic formations, e.g., in the very ancient lavas of the Ventersdorp System in the Divisions of Kimberley and Barkly West, in the Bushveld Amygdaloid of the Transvaal and the Basalts of the Lebombo and Zululand (which all overlie rocks belonging to the Karroo System), and in the volcanic fissure of the Zuurberg in the Cape Colony (probably of post-Neocomian age). They have a striking resemblance to organic structures, and Cohen likens them to certain corals; in some exposures of lava the little pencils of white zeolite studding the surface remind one of the casts of worm burrows.

The pipe-amygdaloid never occurs in the middle or upper portion of a flow, only at the extreme base where the lava rests upon an earlier extrusion or upon sandstone or volcanic ash. In Barkly East pipes have been found in oval masses of lava embedded in sandstone or ash and representing bomb like masses of molten rock ejected from neighbouring volcanic necks. Here too they only appear on the undersides of such masses and never on their upper surfaces.

The rock containing the pipes is usually a vesicular lava, but not necessarily so; sometimes the material may be quite compact without any other vesicles.

The amygdales are commonly from four to six inches in length, with about the diameter of a quill; sometimes they may reach about double that length. The vesicles are cylindrical in cross-section with occasional small swellings, and as they are traced upwards into the flow the tubes are found to unite, giving rise to a branching structure (Fig. 1).

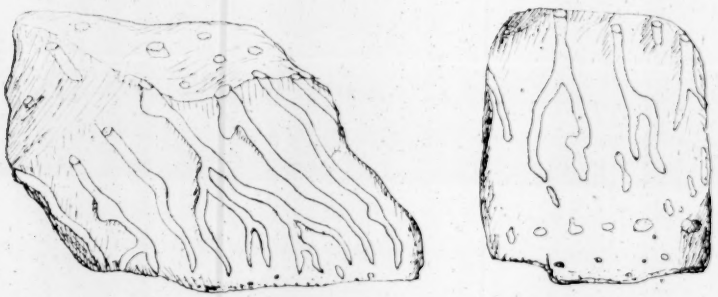


FIG. 1.—Pipe-amygdales in lava from the Drakensberg. In (*a*) the vesicles are inclined to, and in (*b*) are normal to, the base of the lava-flow. (Drawn about $\frac{1}{3}$ nat. size.)

Larger tubes are also found, and are rather irregular in cross-section and constricted at points. The vesicles are filled in with calcite and chalcedonic silica in the case of the Ventersdorp lavas and with zeolites in the later volcanics.

Before discussing the mode of origin of these curious amygdales it will be of advantage to describe certain allied structures found in some of the compact diabasic lavas of the Ventersdorp System of Barkly West.

The lavas, which are buried almost horizontally here, are in places traversed by nearly vertical cylinders of amygdaloidal rock from one to six inches in diameter and with considerable length. Cross-sections are circular, elliptical, crescentiform, or a little irregular in outline; the spacing of these vesicular portions is usually very irregular.

The cylinder walls are clearly defined from the enclosing compact diabase, owing to the occurrence on their peripheries of closely-set vesicles elongated in a vertical direction; apart from their vesicular character, there seems to be no difference in the nature of the material composing them (Fig. 2).

Fig. 2.—Vesicle cylinders in diabasic lava from Barkly West, (*a*) longitudinal fracture along, (*c*) transverse fracture across, a cylinder. In (*b*) a row of vesicles have coalesced to form a 'pipe-amygdale.' (Drawn about $\frac{1}{3}$ nat. size.)

At the town of Barkly West a bed of this diabase rests upon an earlier extruded sheet of amygdaloid, and the lower eight or ten feet of the compact rock is traversed by many cylinders of vesicles. In some of the cylinders certain numbers of the bubbles have coalesced to form irregular pitted cavities, and in one case a long pipe-amygdale, about two-thirds of an inch in diameter, has been produced; ordinary pipe-amygdales are developed in places at the extreme base of the flow.

The cylinders may terminate sharply upwards in the form of a cone-shaped mass of vesicles, or the bubbles may become diffused through the diabase.

The vesicular portions of the rock are more readily attacked by weathering, and surfaces of the diabase exhibit shallow pits. At Nickerk's Rush, on the Vaal River, these hollows are so regularly spaced in the diabase along the river bank as to have led many persons to imagine them to be the footprints of prehistoric animals. The areas are D-shaped in plan and similarly oriented: the convex side apparently indicates the direction of a movement in the lava during its solidification.

Structures having a very great resemblance to, and in some cases apparently identical with, these have been described from the

Melaphyre of Darmstadt by Kuppers,[1] Klem,[2] Wittich,[3] and others under the names of "separation-bodies, contraction-cylinders, and bubble-trains." The lava being rather weathered, the cylinders break out from the melaphyre, but sometimes the continuity of the material still exists in places. Like the Barkly West examples these structures are only found in the lower part of the upper of two lava-flows, the rock above passing into a normal amygdaloid. Wittich explains them on the supposition that the upper portion of the second flow became chilled rather rapidly, so that the bubbles formed from the vapour given out in the lower portion were unable to escape. Kuppers, on the other hand, considers them as due to contraction during solidification. Neither of these views seems to account satisfactorily for the Darmstadt examples, nor will either of them hold in the case of the Barkly West specimens, occurring as they do in a rock which is otherwise devoid of amygdales.

I think there can be little doubt that the gas which filled the vesicles in these structures has not come from the lava-flow itself, but has been derived from cavities and fissures in the rock underlying. The lava being in most cases too mobile for the successful production of pipe-amygdales, the bubbles have ascended from the bottom in continuous rows and thus formed 'bubble-trains.' Vertical sheets of amygdaloidal rock in the diabase probably indicate that the gas has been emitted from a long fissure, while its evolution over a wider area would account for the masses of vesicular material of irregular outline and several square feet in section occasionally seen. It is perhaps even possible that with a great irruption of gas from below, a lava-flow that would otherwise have been compact might in great part become converted into amygdaloidal rock.

The gas may have consisted either of the air entangled in the lower lava-flow or of steam formed by the vapourising of water contained in it or else overlying it. In the case of the Ventersdorp lavas there is not sufficient evidence to show whether they were subaqueous in character, although certain interbedded quartzites point in that direction. The Stormberg lavas, however, contain towards their base intercalations of sandstone, shale, and volcanic ash, and the earlier flows have undoubtedly been erupted subaqueously.

Professor Schwarz[4] has attempted an explanation of the pipe-amygdales based upon Wittich's views, but I think that there is more likelihood of their having been formed by the steam generated in the flowing of the molten rock over moist surfaces; this is the theory adopted to explain the Indian examples.[5]

As Cohen pointed out, the condition essential to the formation of these elongated amygdales was that the lava should be sufficiently viscid. In thin sections of the amygdaloids the vesicular cavities rarely show evidence of having originated prior to the crystallization

[1] Kuppers: Centralblatt für Min. Geol. u. Pal., 1901, pp. 481, 609; 1902, p. 521; 1903, p. 409.
[2] Klem: ibid., 1903, p. 217.
[3] Wittich: Tschermak's Min. u. Petrogr. Mitt., vol. xxi (1902), p. 185.
[4] Schwarz: Ann. Rep. Geol. Commission for 1902, p. 57.
[5] Medlicott & Blanford: "Geology of India," 1893, p. 261.

of most of the felspar; more commonly lath-shaped plagioclases and in many cases prisms and granules of augite project into the hollows.[1] This shows that the lavas as they issued from the volcanic pipes consisted of viscous and partially crystallized material.

In hand specimens the actual base of a flow containing pipe-amygdales for a distance of from a quarter of an inch up to two inches contains small vesicles, or as one may almost term them 'undeveloped pipes.' Above this, where the temperature of the rock would have been greater, the lava is crowded with tubular vesicles which run into one another as they are followed upwards and give rise to a branching structure. After these terminate we may find elongated or irregular vesicles, evidently 'pipes' that have risen bodily through the lava and have become more or less modified by movement and temperature. Sometimes similar amygdales are found above these, but as a rule at a distance of a few feet above the base of the flow the normal rock, vesicular or compact, is found.

Commonly the pipes are arranged perpendicularly to the base of the flow, but sometimes, and this is commonly the case in Barkly East, the amygdales are much inclined. Deviations up to 60 degrees from the normal are found, indicating motion of the lava during their formation.

In some parts of the Drakensberg pipe-amygdaloids are very abundant; close to the town of Barkly East there are over a dozen horizons within a thickness of not more than 200 feet of rock.

An interesting parallel to the way in which I have supposed the pipe-amygdales to have been formed is afforded by some experiments of Messrs. J. T'Anson & E. A. Parkhurst.[2] Bubbles of carbonic acid gas carrying with them some sulphuric acid were allowed to rise through a solution of an alkaline silicate, and formed in their upward passage peculiar delicate, irregular, and branching tubules of colloidal silica much resembling corals.

V.—Notes on some Coastal Features in Co. Waterford.

I. Fornaght Strand.

By F. R. Cowper Reed, M.A., F.G.S.

THE occurrence of 'submerged forests' on the coast of co. Waterford has long been known, though no mention of them was made in the Survey Memoir published in 1865. The more recent discovery of pre-glacial beaches and raised wave-cut rock-platforms along the south coast of Ireland between Baltimore and Carnsore Point[3] has thrown still further light on Post-Tertiary movements of the land-margin; and accordingly some new observations on these phenomena in a hitherto unmarked locality may be of interest.

On the west side of the broad mouth of the River Suir there is an unfrequented bay bounded by Creadan Head on the south and

[1] Ann. Rep. Geol. Commission for 1904, p. 134.

[2] Min. Mag., vol. v (1884), p. 34.

[3] Muff & Wright: Geol. Mag., Dec. IV, Vol. X (1903), p. 501; Sc. Proc. Roy. Dublin Soc., N.S., vol. x (1904), pp. 250–324; "Geology of Country around Cork" (Mem. Geol. Surv. Ireland, 1905, p. 36 et seq.).

Knockavelish Head on the north. The straight stretch of sand and shingle across the head of the bay is known as Fornaght Strand, but on each side the cliffs of the promontories descend abruptly into the sea without any beach exposed at their base, except a narrow strip at low tide in a few coves on the south and a mass of tumbled rocks on the north.

Two typical glaciated valleys, of which the southern one is the larger and longer, unite at the back of the flat expanse of marshy land which lies behind the strand at a slightly higher level; and they are separated by a ridge of Old Red Sandstone, which is the formation composing the whole surrounding area. This median ridge is particularly interesting because it ends abruptly at a distance of over 200 yards from the present sea-margin in a steep slope with a vertical cliff at its base, and in this way descends suddenly to the level of the alluvial flat. That this cliff has been produced by marine erosion and is in fact an old sea-margin is strongly supported (1) by the existence of an old rock-platform preserved beneath the drift deposits at the north end of the strand, and (2) by the occurrence of distinct traces of the same feature as a shelf cut in the face of the massive Old Red conglomerate cliffs of Knockavelish Head, which bounds the bay on the north. This shelf must be regarded as the much reduced remnant of a rock-platform; its continuity has been interrupted by subsequent erosion and its width narrowed to 3 to 4 feet. It stands at a height of about 10–15 feet above the shore-platform which is now being formed by wave-erosion, and at about 4–5 feet above the present high-water mark. The level of this rocky ledge corresponds roughly with the base of the inland cliff above mentioned, though the latter seems rather higher owing to the subsequent accumulation of superficial deposits round its foot. On the opposite side of the bay this rock-cut terrace cannot be well traced, probably owing to the nature of the cliffs of Creadan Head, which consist of nearly horizontal soft sandstone beds at sea-level with occasional intercalated thin bands of conglomerate, so that they have been rapidly undermined and worn away. But inland up the Creadan valley traces of the old sea-cliff can still be observed.

Returning now to the north end of Fornaght Strand, we find a line of cliffs running for about 150 yards nearly at right angles to the trend of the Old Red southern flank of Knockavelish Head. They rise gradually from sea-level to a height of about 40 feet at their northern end, where they end abruptly against the headland. These cliffs are composed of sand, gravel, 'head,' and Boulder-clay banked up against the solid rock of the northern flank of the valley, and they rest on a platform of Old Red conglomerate and Ordovician slates and flags which slopes up gently northwards. This platform is well levelled, and forms the old plane of marine erosion at the base of the inland sea-cliff, though its extension inwards to the latter is covered by the drift and other deposits of the alluvial flat. The subsequent erosion by the sea of the northern side and floor of this partially filled valley has caused the formation of this interesting section in the drift deposits. The actual junction of the latter with the solid rocky side of the valley is somewhat obscured by

slipped material and rainwash, and overgrown with vegetation. But it is most suggestive of the source of the bedded materials in the cliff to find that the deposits, though somewhat irregular and impersistent, dip away from the valley-side towards the south or S.S.E. at an average angle of 15°, and thin out rapidly in the same direction, thus agreeing with the present surface contour of the valley floor and with the top of the cliffs. The following succession of beds can be best traced (in descending order) at a distance of about 30 yards from the northern corner of the bay, but they undergo considerable changes in character and thickness or even disappear when followed south, as noted below:—

	Feet.
(1) Soil, occasionally containing cockle-shells scattered irregularly or in patches, especially where the cliff is low at its southern end	½–1
(2) Yellow loam or clay with a few subangular and rounded stones, thinning out northwards and becoming indistinguishable from the bed below, into which it also passes down	3–5
(3) Dark brown stony loam ('head'), sandy and with fewer stones near top, but mostly filled with angular fragments rather closely packed, from the size of a pea to 3 inches in length; interstices filled with loam; distinctly bedded, but varying in coarseness. Thickens northwards. Rests on irregular (? eroded) surface of bed below. Continuous for whole length of cliffs	3–4
(4) Brownish Boulder-clay, unbedded, containing a few large stones or boulders. Thins out rapidly northwards, but increases rather suddenly in thickness southwards and then forms base and lower half of greater part of cliffs	1–20
(5) Loamy clay containing few boulders at top, where it passes imperceptibly up into No. 4, but in its lower part the stones (which are mostly subangular and of all sizes up to 8 inches in length) become more numerous, and are quite irregularly distributed irrespective of size, though sometimes obscurely arranged in parallel lines. At the base of the bed they are cemented together in places by iron oxide ('terricrete'). The whole bed is thickest where No. 4 is thinnest, and rapidly wedges out and disappears to the south below the typical Boulder-clay. A large lenticular mass of white sand is a conspicuous feature in one place	0–15
(6) Wedge-shaped bed of small, loosely packed, flat fragments of slate averaging ¼ inch to 1 foot in size with rounded edges and arranged in definite layers; interstices filled with a little loam. Bed thins out rather rapidly to south and becomes inseparable from the base of No. 4, which there rests directly upon it. At its base there are a few large irregular blocks of Old Red Sandstone conglomerate, one measuring 3 feet by 1 feet	0–3
(7) White sandy loam passing down into fine, yellow, argillaceous sand without any pebbles or boulders. Sharply marked off from Nos. 6 and 8	3–4
(8) Coarse, sandy, and argillaceous gravel, composed of pebbles from Old Red Sandstone conglomerate	4

The greater part of the cliffs, however, does not exhibit such a full and varied sequence of deposits, and in fact only consists of beds 4, 3, 2, and 1, the southerly dip having carried the others (where they have not already thinned out) below the present beach-level.

Comparing the full succession of beds with that described by Messrs. Wright & Muff as resting on the Cork pre-glacial terrace, we may fairly recognise in beds 8 and 7 the equivalent of their 'raised beach gravel and sand' and perhaps of the 'blown sand' of many of their

sections.[1] Bed No. 6 may possibly correspond with their 'Lower Head,' though this bed and No. 5 are rather different in their development and show more sorting of the materials by water, suggesting a rearrangement of the 'head' or a modified rainwash, perhaps in early glacial times, so that they ought to be reckoned rather as stratified early glacial gravels. The thickening, however, of these beds towards the valley-side and the development of 'ferricrete' at their base, together with the inclusion of large tumbled masses from the old cliff at the base of which they accumulated, are points in common with the deposit termed 'Lower Head' on the Cork coast. 'The Boulder-clay,' No. 4 of our section, followed by the 'Head,' No. 3, agree precisely in their relations, and to a large extent in their general characters, with those of Cork. It should be remembered, moreover, that there is considerable variation even along the latter coastline in the character, development, and sequence of deposits as described by the above-mentioned authors, and that a precise correspondence of the beds on Fornaght Strand can scarcely be expected. The important features insisted on by Messrs. Wright & Muff are the buried rock-cliff and the wave-cut rock-platform; and in the characters of these and the height above the present plane of wave-erosion and of high-water mark the correspondence is so close that we cannot doubt that we are dealing with the same features and phenomena.

A late downward movement[1] of the coastline is indicated by the 'submerged forest' of Fornaght Strand, which does not appear to have been previously noticed, though Hardman[2] in 1873 referred to the one near Tramore as a "partially submerged or silt-covered bog," and Kinahan[3] mentioned various submerged bogs (including the latter one) on the south-east coast of Ireland.

The shore of Fornaght Strand shelves very gently down to the sea, and about 30 to 40 feet from high-water mark (horizontal distance) the edge of the sheet of peaty soil appears in which the tree-stumps are rooted. It forms a wide flat, sloping down slightly and extending to an unknown distance seawards below low-water mark, even at spring tides. It is often covered up with sand and not visible near the beach at ordinary low tides. The tree-trunks measure 1 to 1½ feet in diameter at the level at which they are broken off, which is, as usual, fairly uniform and close to their base. About thirty rooted stools were counted by me on my last visit there this Summer.

VI.—The Evolution of *Stomatopora dichotomoides* (d'Orbigny).

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

ALECTO DICHOTOMOIDES was the name given by d'Orbigny[4] in 1849 to a specimen figured by Michelin[5] in 1841 from the

[1] Geikie: Pres. Add. Geol. Soc., 1904, p. xcvi.

[2] Hardman: Journ. Roy. Geol. Soc. Ireland, n.s., vol. iv (1877), p. 31 (read December, 1873). See also Geol. Mag., 1874, pp. 210–215.

[3] Kinahan: "Geology of Ireland," 1877, p. 265.

[4] A. d'Orbigny: Prodrome de Paléontologie stratigraphique universelle, 1849, vol. i, p. 288; and Paléontologie Française, Terrains Crétacés, vol. v (1854), pp. 834, 835.

[5] H. Michelin: Iconographie Zoophytologique, 1840, pl. ii, fig. 10.

Bajocian of Bayeux, or of Moutiers, Calvados, Normandy, and identified by Michelin as *A. dichotoma*, Lamouroux.

Haime[1] recognised d'Orbigny's name, and under it figured a specimen from the Aalenian of Postlip, north-east of Cheltenham, Gloucestershire, in the Walford Collection, now in the Sedgwick Museum, Cambridge. Haime's type, however, differs slightly from Michelin's figure, having larger and less pyriform zoœcia. But the chief point to be noticed is the extreme simplicity of characters in both.

In a paper[2] on the Liassic forms of *Stomatopora* three lines of descent were traced upwards as far as the *capricornus* zone of the Lias. Two of these stocks were already differentiated to such an extent that it cannot be supposed that *S. dichotomoides* (d'Orbigny) is descended from them; for the simplicity of this species shows no signs of being secondary. It is probable, therefore, that this Aalenian form is the direct descendant of the third series, of which the last term was *S. Gregoryi*, mutation *capricornensis*, Lang, from which *S. dichotomoides* (d'Orbigny) differs only in the greater pyriformation of the zoœcia.

Form 3 — the Bajocian form — is the type of *S. dichotomoides* (d'Orbigny), so that Form 2 would be called *S. dichotomoides* (d'Orbigny), mutation *Marchisonensis*, according to the nomenclature advocated in the former paper, because it occurs in the zone of *Ludwigia Murchisonæ*. Otherwise the specific names remain unaltered.

It is to be doubted whether Vine's form *S. intermixta* differs at all from the type of *S. dichotomoides*. His type of this species and of *S. Phillipsi* cannot be found, though his collection is in the British Museum. But his figures of *S. intermixta*[3] and of *S. Phillipsi*[4] remain, and cannot be ignored. The diagram of *S. Smithi* is taken from the figure in the British Museum Catalogue.[5] The type is in the York Museum.

The only form of which sufficient material is available for tracing the changes in characters during the life-history is in the mutation *Marchisonensis*, of which Haime's type of *S. dichotomoides* is a good example. The following description defines this form:—

Zoarium loose and spreading, branching only after Type 1.[6] The angle at the first dichotomy is 180°, after which it diminishes regularly to about 45° at the sixth dichotomy. The number of peristomes between each dichotomy is generally one, sometimes two. There seems to be no regular sequence in the variation of this character. The length of the zoœcia at the first dichotomy is about 2½–3½, increasing to 3½ at the third dichotomy and gradually decreasing again

[1] J. Haime, "Description des Bryozoaires fossiles de la formation Jurassique": Mém. Soc. géol. France, ser. II, vol. v (1854), pp. 163, 164, pl. vi, fig. 2.

[2] W. D. Lang: Geol. Mag., 1905, p. 258.

[3] G. R. Vine, "Polyzoa from the Combrash of Thrapston": Proc. Yorks Geol. & Polytech. Soc., vol. xii (1893), p. 252, pl. xii, fig. 4.

[4] G. R. Vine: loc. cit., p. 250, pl. xii, fig. 1.

[5] J. W. Gregory: Brit. Mus. Cat. Jur. Bry., 1896, p. 56, fig. 8, which is a reproduction of Gregory's figure in "The Jurassic Bryozoa of the York Museum" (Rep. Yorks Phil. Soc., 1895, p. 58, fig. 1).

[6] For the terminology employed see Lang, "Jurassic forms of the 'genera' *Stomatopora* and *Proboscina*": Geol. Mag., 1904, p. 319.

The following diagram shows these forms and three others which complete the series in the Bathonian; and from it can be seen the changes accompanying the shape and length of the zoœcia in passing from the lower to the higher horizons:—

6. *Cellaria Smithi*, Phillips: Cornbrash, Scarborough, Yorkshire.

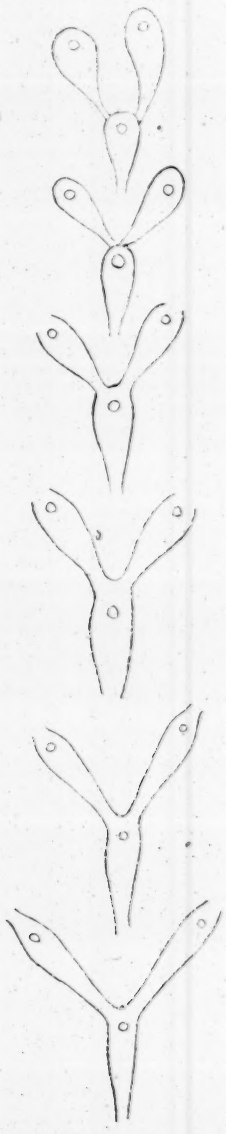
5. *Stomatopora Phillipsi*, Vine: Cornbrash, Thrapston, Northamptonshire.

4. *Stomatopora intermista*, Vine: Cornbrash, Thrapston, Northamptonshire.

3. *Aberia dichotoma*, Michelin: Bajocian, Calvados, Normandy. = *Aberia dichotomoides*, d'Orbigny.

2. *Stomatopora dichotomoides*, Heime: Aalenian, Peacock Pool, Postlip. = *Stomatopora dichotomoides* d'Orbigny), mutation *Murchisonensis*.

1. *Stomatopora Forgarii*, mutation *capricornensis*, Lang: Lias, '*capricornus*' zone, Cherington, Warwickshire.



Evolution of *Stomatopora dichotomoides* (d'Orbigny).

distally. The shape of the zoœcia is slightly pyriform at first, becoming more so distally. Haime's figure makes them appear a little too pyriform. The zoœcia are very slightly ribbed throughout.

The actual measurements of two specimens of this form are given in the following table with those of the fragmentary zoœcia which represent the other forms. It will be seen that as far as can be

Type of Branching.	Haime's type of *S. dichotomoides*: Aalenian, Postlip.	British Museum specimen B 2287 (8), 2 zoœcia: Aalenian, Crickley.	Michelin's figure of *Alecto dichotoma*: Bajocian, Bayeux.	Vine's figure of *S. intermixta*: Cornbrash, Thrapston. ? $x = 2$.	Vine's figure of *S. Phillipsi*: Cornbrash, Thrapston. ? $x = 3$.	Gregory's figure of *S. Smithi*: Cornbrash, Scarborough. ? $x = 4$.
At dichotomy 1	I. 180°	I. 180°	I. 180°			
,, ,, 2	I. 120°	I. 120°–160°	I. 120°	I. 120°		
,, ,, 3	I. 80°–90°	I. 90°–120°	I. 90°–120°	I. 120°	I. 80°	
,, ,, 4	I. 60°–80°	I. 90°	I. 45°–60°	I. 60°	I. 80°	I. 60°
,, ,, 5	I. 45°–50°	...	...	I. 90°		
,, ,, 6	I. 45°–60°					
Number of Peristomes between each Dichotomy.						
Before dichotomy 1 ...	?	? 2	2			
Between dichotomies 1 and 2	1	1–2	1			
,, ,, 2 ,, 3	1	1	1	1		
,, ,, 3 ,, 4	1	1	1–2	1	1	1–2
,, ,, 4 ,, 5	1–2	...	1–2	1	...	1–2
,, ,, 5 ,, 6	2					
Ratio of Length of Zoœcium to Breadth: Breadth = 1.						
Before dichotomy 1 { Zoœcium 1	?	...	$1\frac{1}{2}$			
,, ,, 2	?	? 2	2			
At dichotomy 1	$2\frac{1}{2}$	$2\frac{1}{2}$–4	2			
,, ,, 2	3	3–$3\frac{1}{2}$	2	$2\frac{1}{2}$		
,, ,, 3	3	3–$3\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	
,, ,, 4	$3\frac{1}{2}$	$2\frac{1}{2}$–3	2–$2\frac{1}{2}$	2	$2\frac{1}{2}$	$2\frac{1}{4}$
,, ,, 5	3					
,, ,, 6	3					
Shape of Zoœcium.	Rather pyriform.	Cylindrical or very slightly pyriform before 1. 1–2 slightly pyriform. 3–6 pyriform.	*Before 1.* 1. Cylindrical. 2. ? Slightly pyriform. *After 1.* Pyriform.	Pyriform.	Pyriform.	Hippothoiform.
Ornamentation.	Very slightly ribbed throughout.	Very slightly ribbed throughout.	?	Slightly ribbed.	?	?

determined the only changes throughout the series are in the shape of the zoœcia, which pass from slightly pyriform to hippothoiform, accompanied by a change in length from more than 2½ to less than 2½.

It is probable that the more primitive forms of this series persisted into and through Bathonian times, and were the ancestors of at least the primitive forms of the Middle Oolites. So that the direct line of descent would not pass through *S. Smithe* (Phillips), but rather this specialised form is the end of a side branch which includes *S. Phillipsi* (Vine) and *S. intermixta* (Vine). The line of forms represented in the diagram should in this case bend aside in the middle. But Bathonian forms as primitive as *S. dichotomoides* (d'Orbigny) have yet to be discovered.

VII.—Some Clay Beds by the Ouse.

By Beeby Thompson, F.G.S., F.C.S.

IN the maps of the Geological Survey, Quarter-sheet No. 52, S.W. (Bedford), published in 1863, Upper Lias Clay is shown as bordering the Ouse Valley between Stoke Goldington and Olney, directly overlaid by the Great Oolite, that is to say, the maps indicate an entire absence of the Inferior Oolite (Northampton Sand).

The only exposure of the clay I have seen is at Stoke Goldington brickyard, and until a few weeks back the only fossils I could find there were a few belemnites, but from these belemnites and the general appearance of the clay I felt quite satisfied as to its being Upper Lias.

In Mr. H. B. Woodward's "Jurassic Rocks of Britain," vol. iii, p. 277, occurs the following passage: "Inlying exposures of Upper Lias have been mapped at Stoke Goldington and Weston Underwood, between Olney and Newport Pagnell. I have examined the exposures in company with Mr. A. C. G. Cameron, and we found no evidence of Upper Lias. The clays exhibit green and purple tints, like the Upper Estuarine Beds, with which I think they should be grouped. The occurrence of 'Nail-head spar' in the clay at Stoke Goldington brickyard might be taken as suggestive of Upper Lias; but bands of fibrous carbonate of lime, or 'beef,' are not uncommon in the Upper Estuarine Beds, and the 'cone-in-cone' structure of the nail-head spar seems to be intimately connected with the 'beef.' It is, however, not unlikely that in this neighbourhood, as further westward, the Estuarine clays may, in places, rest directly on Upper Lias Clay, for the Northampton Sands become much attenuated, and may not always be present." A similar description of the same beds occurs at pp. 393–4 of Mr. H. B. Woodward's "Jurassic Rocks of Britain," vol. iv.

Knowing what a very careful stratigraphical geologist my friend Mr. H. B. Woodward is, I felt inclined to drop my own opinion, which I could not satisfactorily confirm, and accept his, for which better evidence seemed to be offered, but being in the neighbourhood in August last with Master Gerard Thornton, an enthusiastic young geologist with a keen eye, I thought it would be a good opportunity to make a gallant attempt to solve the problem of the clay beds at

Stoke Goldington. The attack was a short one, and the victory complete for the Upper Lias theory. Below is the section then made:—

SECTION AT STOKE GOLDINGTON BRICKYARD (August, 1906).

	ft.	in.
1. SOIL	2 feet to	3 0
2. RIVER GRAVEL. A gravel almost exactly like that to be found at several other places between here and Olney, containing chalk, flint, Bunter pebbles, Great Oolite limestone, etc.	1	0
In one part of the section only there is a kind of junction clay containing fragments of *Ostrea*, and therefore probably Oolitic in origin, though not necessarily so. Thickness not more than about 6 inches.		
3. UPPER LIAS CLAY. Good typical material, not variegated, not bleached, not disturbed. Containing some iron pyrites in thin slabs, also larger pieces up to 2 or 3 lbs. in weight. The iron pyrites is not obtrusive in the clay, either as lumps or by discoloration	8	0

Fossils found:—

Ichthyosaurus (vertebra).
Ammonites fibulatus (singly and in bunches).
Ammonites of the *subplanatus* group? (fragments).
Belemnites and phragmocones (fragmentary).
Cerithium costellatum, Munst. (part only, but that good).

The clay has been proved to be the same for a further depth of 10 feet by means of a well (or sump), so that a uniform clay extends for a depth of at least 18 feet below the river gravel. The fossils recorded above came from below the 8 feet now exposed, say from a depth of 10 feet at least; and considered in conjunction with the rareness of all fossils, they indicate the upper part of the 'Unfossiliferous' beds a little below the '*Cerithium*' beds or 'Lower *Leda-ovum*' beds of Northamptonshire,[1] *Cerithium costellatum* being one of the forms nearly always found associated with the abundant *Cerithium armatum*. Mr. Woodward's record of 'Nail-head spar' fits in admirably with the horizon suggested.

In my own cabinets the fossils from the unfossiliferous beds (of Judd) are labelled "Fibulatus" zone, not that *Ammonites fibulatus* is confined to the zone; indeed, the best specimens I have come from the *Leda-ovum* beds of the south-western parts of Northamptonshire,[2] but because for some 70 feet of Upper Lias, at least in Northamptonshire, it is the only ammonite that one is pretty certain to find traces of, and if it is found where all other fossils are very rare the zone is identified, but near the bottom and near the top of the zone other fossils are not quite so rare.

Some interesting problems are suggested by the occurrence of such comparatively low beds of the Upper Lias on the border of the Ouse Valley, such as—Are the upper beds of the Upper Lias missing? Does the Great Oolite rest directly on the Upper Lias? Is the Northampton Sand entirely absent, and if absent, why? etc. We will consider the evidence available on these points.

[1] Beeby Thompson, "The Upper Lias of Northamptonshire," pt. vi: Journ. Northants Nat. Hist. Soc., vol. v (1888), p. 54.

[2] *Ammonites fibulatus* appears to continue into successively higher beds of the Upper Lias as we go in a south-westerly direction.

The top of the Lias Clay at Stoke Goldington is at about 188 feet above O.D.,[1] and this is certainly very near to the level of the top of the Lias Clay at two other sections to the eastward, within a mile or so, where river gravel is worked to a depth of 191 feet O.D., showing that in this particular area the top surface of the clay is determined by (comparatively) recent diluvial action, and that higher beds may be reasonably expected to occur near at hand where diluvial action has not been operative.

In the absence of exposures of rock at a higher level at Stoke Goldington the problem was treated in this way:—Going to the N.N.W., we find the base of the Great Oolite limestone at Piddington to be at about 300 feet O.D. At a point on the road between Horton and Stoke Goldington, about $2\frac{1}{8}$ miles from Piddington in a straight line, the probable base of the Great Oolite limestone is 260 feet O.D. A fall of 40 feet in the distance named means an average dip of 14 feet per mile along the line indicated; consequently at Stoke Goldington, $4\frac{7}{8}$ miles from Piddington, there should be a drop of 55 feet, making the natural base of the Great Oolite limestone there 245 feet O.D.

Again, at Ravenstone the base of the Great Oolite limestone appears to be about 250 feet O.D. (an investigation of several wells indicated this figure), and as the middle part of this village, where the Great Oolite source of water gives place to a gravel source, is $3\frac{1}{8}$ miles from Piddington in a direct line, this also gives a dip of close to 14 feet per mile. Furthermore, at a point about $\frac{3}{4}$ mile south of Ravenstone, towards Ravenstone Mill, Great Oolite limestone may be seen in an old quarry as low as about 240 feet O.D., which comes to nearly the same figure, viz., 14 feet per mile dip in a southerly direction. This last section is about one mile from Stoke Goldington brickyard, and as they are N.E. and S.W. of each other respectively, and the dip is distinctly greater south-eastward than southward, it appears highly probable that the former estimate for the natural position of the base of the Great Oolite limestone at Stoke Goldington is about correct, viz. 245 feet O.D. This naturally leaves 245—188 = 57 feet to be filled up; the only question is what with?

As there is no recognisable Northampton Sand, either ironstone or Lower Estuarine sands, in the area under review, the disposition of the 57 feet is left with the Upper Estuarine beds and the upper beds of the Upper Lias.

Near to Olney, half a mile north of the railway station, and a little over 4 miles north-east of Stoke Goldington, a well was sunk through 27 feet of Upper Estuarine beds,[2] and as this is a very good thickness for the beds in question, and yet not greatly different from the thickness of the same beds at Roade cutting (24 feet 10 inches), a little over 6 miles to the north-west of Stoke, we may fairly well accept it as the local thickness, and if we do it leaves 30 feet to be made up with Upper Lias at Stoke Goldington.

[1] All levels were taken with a Watkin aneroid barometer on a moderately satisfactory day for such work, but of course require revision for strict accuracy.

[2] H. B. Woodward: "Jurassic Rocks of Britain," vol. iv, p. 394.

Next let us consider the beds near to Olney. The greater part of the town of Olney is supplied with water by shallow wells in the Ouse Valley gravel, but in the southern part of the town, between the Market Place and the river, and south-westward, on the road to Weston Underwood, the wells are from 60 to 80 feet deep in Lias Clay. It has been assumed that the difference in depth is due to an unconformity between the Upper Lias and the Upper Estuarine beds.[1] Personally I can see no reason whatever for this assumption, for no surface irregularity in the upper beds, not relied upon for water, could possibly alter the level above ordnance datum at which water is found. Wells are not all started at the same level, and if they were some might have a deeper sump than others. However, here is some evidence bearing upon this question of unconformity and other points.

At the extreme south-eastern end of Olney, and on the south side of the road, there used to be a brickyard (the excavation can still be seen). Mr. Cameron reports[2] that the beds worked were yellow and blue clay, and that there was a sand bed one foot thick at the depth of 8 feet from the surface. It is suggested that this sand bed may perhaps be a representative of the Northampton Beds (see remarks later).

Not many yards eastward of this disused brickyard a well has been made for the supply of some cottages, and the report given to me of this well was that it was 80 feet deep, all in blue clay, and that they got water from a black rock 2 feet thick, below which blue clay was again met with; the water rose 50 feet from the rock.

A little westward of the old brickyard, just about where the hill begins to rise sharply, a small excavation made in levelling for a hayrick exposes about 3 feet of a light-coloured oyster marl. Seven feet below the top of this, water flows from the bank.

The levels hereabouts are as follows:—

	Above O.D.
Water-level in the river	163 feet.
Level of spring from marl (base of Upper Estuarine beds?) ...	182 ,,
Well-top at houses	187 ,,
Top of clay at old brickyard ... ... certainly near to	182 ,,

Further along the very steep cliff bordering the Ouse Valley between Olney and Weston Underwood, limestone or marl was found at various places between the levels of 211 feet O.D. and 229 feet O.D. So far as it goes this is satisfactory, for without correction it would mean Upper Estuarine beds not more than $211 - 182 = 29$ feet thick and Great Oolite limestone not less than 18 feet. The highest exposure of limestone coincided with the fence, but the roadway is six feet higher, and obviously at least this amount must be added to the limestone, making it 24 feet, so that not much need be added to it below.

If we consider that the base of the Upper Estuarine beds at Stoke Goldington is correctly indicated by the level $245 - 27 = 218$ feet O.D., and at Olney by 182 feet O.D., then there is a dip from the former locality to the latter of 36 feet, or $9\frac{1}{2}$ feet per mile, and this same dip

[1] Ibid.
[2] Ibid., p. 394.

The top of the Lias Clay at Stoke Goldington is at about 188 feet above O.D.,[1] and this is certainly very near to the level of the top of the Lias Clay at two other sections to the eastward, within a mile or so, where river gravel is worked to a depth of 191 feet O.D., showing that in this particular area the top surface of the clay is determined by (comparatively) recent diluvial action, and that higher beds may be reasonably expected to occur near at hand where diluvial action has not been operative.

In the absence of exposures of rock at a higher level at Stoke Goldington the problem was treated in this way:—Going to the N.N.W., we find the base of the Great Oolite limestone at Piddington to be at about 300 feet O.D. At a point on the road between Horton and Stoke Goldington, about $2\frac{5}{8}$ miles from Piddington in a straight line, the probable base of the Great Oolite limestone is 260 feet O.D. A fall of 40 feet in the distance named means an average dip of 14 feet per mile along the line indicated; consequently at Stoke Goldington, $4\frac{1}{8}$ miles from Piddington, there should be a drop of 55 feet, making the natural base of the Great Oolite limestone there 245 feet O.D.

Again, at Ravenstone the base of the Great Oolite limestone appears to be about 250 feet O.D. (an investigation of several wells indicated this figure), and as the middle part of this village, where the Great Oolite source of water gives place to a gravel source, is $3\frac{11}{16}$ miles from Piddington in a direct line, this also gives a dip of close to 14 feet per mile. Furthermore, at a point about $\frac{3}{4}$ mile south of Ravenstone, towards Ravenstone Mill, Great Oolite limestone may be seen in an old quarry as low as about 240 feet O.D., which comes to nearly the same figure, viz., 14 feet per mile dip in a southerly direction. This last section is about one mile from Stoke Goldington brickyard, and as they are N.E. and S.W. of each other respectively, and the dip is distinctly greater south-eastward than southward, it appears highly probable that the former estimate for the natural position of the base of the Great Oolite limestone at Stoke Goldington is about correct, viz. 245 feet O.D. This naturally leaves $245 - 188 = 57$ feet to be filled up; the only question is what with?

As there is no recognisable Northampton Sand, either ironstone or Lower Estuarine sands, in the area under review, the disposition of the 57 feet is left with the Upper Estuarine beds and the upper beds of the Upper Lias.

Near to Olney, half a mile north of the railway station, and a little over 4 miles north-east of Stoke Goldington, a well was sunk through 27 feet of Upper Estuarine beds,[2] and as this is a very good thickness for the beds in question, and yet not greatly different from the thickness of the same beds at Reade cutting (24 feet 10 inches), a little over 6 miles to the north-west of Stoke, we may fairly well accept it as the local thickness, and if we do it leaves 30 feet to be made up with Upper Lias at Stoke Goldington.

[1] All levels were taken with a Watkin aneroid barometer on a moderately satisfactory day for such work, but of course require revision for strict accuracy.

[2] H. B. Woodward: "Jurassic Rocks of Britain," vol. iv, p. 394.

Next let us consider the beds near to Olney. The greater part of the town of Olney is supplied with water by shallow wells in the Ouse Valley gravel, but in the southern part of the town, between the Market Place and the river, and south-westward, on the road to Weston Underwood, the wells are from 60 to 80 feet deep in Lias Clay. It has been assumed that the difference in depth is due to an unconformity between the Upper Lias and the Upper Estuarine beds.[1] Personally I can see no reason whatever for this assumption, for no surface irregularity in the upper beds, not relied upon for water, could possibly alter the level above ordnance datum at which water is found. Wells are not all started at the same level, and if they were some might have a deeper sump than others. However, here is some evidence bearing upon this question of unconformity and other points.

At the extreme south-eastern end of Olney, and on the south side of the road, there used to be a brickyard (the excavation can still be seen). Mr. Cameron reports[2] that the beds worked were yellow and blue clay, and that there was a sand bed one foot thick at the depth of 8 feet from the surface. It is suggested that this sand bed may perhaps be a representative of the Northampton Beds (see remarks later).

Not many yards eastward of this disused brickyard a well has been made for the supply of some cottages, and the report given to me of this well was that it was 80 feet deep, all in blue clay, and that they got water from a black rock 2 feet thick, below which blue clay was again met with; the water rose 50 feet from the rock.

A little westward of the old brickyard, just about where the hill begins to rise sharply, a small excavation made in levelling for a hayrick exposes about 3 feet of a light-coloured oyster marl. Seven feet below the top of this, water flows from the bank.

The levels hereabouts are as follows:—

	Above O.D.
Water-level in the river	163 feet.
Level of spring from marl (base of Upper Estuarine beds?) ...	182 ,,
Well-top at houses	187 ,,
Top of clay at old brickyard ... ... certainly near to	182 ,,

Further along the very steep cliff bordering the Ouse Valley between Olney and Weston Underwood, limestone or marl was found at various places between the levels of 211 feet O.D. and 229 feet O.D. So far as it goes this is satisfactory, for without correction it would mean Upper Estuarine beds not more than $211 - 182 = 29$ feet thick and Great Oolite limestone not less than 18 feet. The highest exposure of limestone coincided with the fence, but the roadway is six feet higher, and obviously at least this amount must be added to the limestone, making it 24 feet, so that not much need be added to it below.

If we consider that the base of the Upper Estuarine beds at Stoke Goldington is correctly indicated by the level $245 - 27 = 218$ feet O.D., and at Olney by 182 feet O.D., then there is a dip from the former locality to the latter of 36 feet, or 9½ feet per mile, and this same dip

[1] Ibid.
[2] Ibid., p. 394.

would take the horizon of the Lias beds exposed at Stoke Goldington to a level of 188 − 36 = 152 feet O.D., which is 11 feet below river level, so obviously any sections of Upper Lias exposed between Stoke Goldington and Olney would consist of higher and higher beds as one approached the latter place, and this may easily in part account for Mr. Woodward's description of the clay beds in this area not agreeing with my own, though of course he also saw some Upper Estuarine exposures.

I quite believe that the uppermost clay beds towards Olney, here described as Upper Lias, may well represent, in time, the Northampton Sand, as I have previously suggested that the highly pyritous clays do at Grafton Regis, some few miles to the west.[1]

No unconformity between the Lias and Oolites in the area under consideration has been actually detected, and with the above explanations one is not needed; moreover, it would be somewhat difficult to account for if it occurred in an area which was sinking throughout the later Liassic and the whole of the remainder of the Jurassic period; as is evidenced by the formations which are absent as well as those present in districts further to the south and south-east, indicated by the deep borings, etc.

VIII.—On some Fossiliferous Keuper Rocks at Bromsgrove (Worcestershire).

By L. J. Wills, B.A., King's College, Cambridge.

THE counties of Warwick and Worcester have yielded the majority of Keuper fossils recorded from England. The history of their discovery commenced about seventy years ago with a paper by Murchison and Strickland,[2] where there is a description of the area. They distinguished two divisions, the lower of which they identified as Bunter, chiefly on the evidence of a plant, *Echinostachys oblongus*, Brongn. This division was found to be, for the most part, composed of sandstones, and contained in Worcestershire plant remains and in Warwickshire bones and teeth. The localities where fossils were found were Ombersley, Hadley, Elmley Lovett, all on the west side of the Droitwich basin, Bromsgrove on the east of it, and in the Warwick district.

Their upper division was composed of marls with intercalated sandstones in some places. This they referred to the Keuper. They held that the sandstones of Burge Hill, Pendock, Inkberrow, and Shrewley, although very scattered, represented a definite horizon in the marls. They recorded fossils from these localities.

Professor Hull, in 1869, corrected the nomenclature and recognised an unconformity between the true Bunter and Keuper in England in the place of the Muschelkalk. His divisions of the Lower Keuper (Murchison and Strickland's Bunter) are:—

[1] "Junction-Beds of the Upper Lias and Inferior Oolite in Northamptonshire": Journ. Northants Nat. Hist. Soc., vol. xii (No. 94, June, 1903), pp. 68–69.

[2] Murchison & Strickland: Trans. Geol. Soc., ser. II, vol. v (1837), p. 331.

[3] E. Hull, "Permian and Triassic Rocks of the Midlands": Mem. Geol. Surv., 1869.

1. Waterstones: micaceous laminated sandstones and beds of marl.
2. Building-stone: thick non-micaceous sandstones.
3. Basement beds: sandstones, conglomerates, and calcareous sandstones.

Although Hull dealt with the whole of the Midland counties, he noticed no plants from the Lower Keuper except those from Worcestershire, which had been described by Murchison and Strickland, and none of the newer Survey Memoirs has supplied any further records. His memoir contains a valuable list of fossils, to which only a few have since been added.

With the exception of Owen's[1] and of Miall's[2] descriptions of the Labyrinthodont remains in the Warwick Museum, and of Huxley's note on *Hyperodapedon*[3] and a few other descriptive papers, including those in the recent British Association Reports,[4] nothing has since been written about the Lower Keuper of these counties.

I purpose, at present, to deal more especially with the Lower Keuper of Bromsgrove. But since the beds here are rich in plant remains, it may be of interest to note those plants that have been recorded from the Upper Keuper. In 1855 W. S. Symonds[5] described the Pendock Beds, and mentions plants which were identified as belonging to either *Calamites arenaceus* or *Equisetites columnaris*, but which were more probably *Equisetites arenaceus*. In the following year J. Plant[6] noticed *Equisetum* from Leicester, while vegetable remains, including "*Voltzia* in fructification," *Calamites*, and *Carpolithes*, were recorded by P. B. Brodie from Shrewley and Rowington,[7] to which J. Phillips added *Walchia hypnoides*.[8] Their specimens, in so far as they still exist, are in too poor a state of preservation to allow of re-identification. I have added one new locality, south-east of Green Lane Farm, Callow Hill, in Worcestershire, where indeterminable plant remains have been found associated with *Estheria*. The above records point to the scarcity of the flora and illustrate the doubtful nature of many of these identifications.

The beds at Bromsgrove in which I have found fossils are the Waterstones and upper part of the Building Stone of Hull's classification, which are extensively quarried on the hill about a mile to the south-west of Bromsgrove, known as Rock Hill and Hill Top. The four quarries belong alternately from south to north to Mr. Willcox and Mr. Griffin, to both of whom I am much indebted for assistance. The beds show alternations of sandstone and shales, and a band of marl conglomerate, the whole dipping at a low angle to the south. The shales thicken and thin out in a most extraordinary way, which makes any measurements and comparisons of the beds in the

[1] R. Owen: Trans. Geol. Soc., ser. II, vol. vi (1842), p. 503; and Palæontology, 2nd ed. (Edinburgh, 1861), p. 278.
[2] L. C. Miall: Q.J.G.S., vol. xxx (1874), p. 417.
[3] T. H. Huxley: Q.J.G.S., vol. xxv (1869), p. 138.
[4] Reports of Trias Committee of British Association, 1903, 1904, 1905, 1906.
[5] W. S. Symonds: Q.J.G.S., vol. xi (1855), p. 450.
[6] J. Plant: Q.J.G.S., vol. xii (1856), p. 373.
[7] P. B. Brodie: Q.J.G.S., vol. xii (1856), p. 374; vol. xliii (1887), p. 540; vol. xlix (1893), p. 171.
[8] J. Phillips: "Geology of Oxford and Thames Valley," p. 97; Oxford, 1871.

various quarries practically impossible. This variation is quite in keeping with the false bedding seen throughout in the sandstones. (See Fig. 1.)

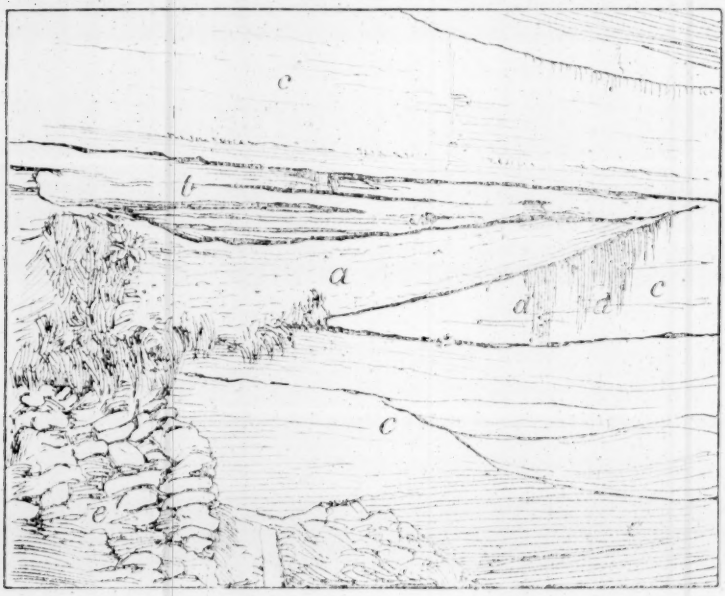


Fig. 1.—Section seen in Mr. Griffin's quarry.

a. Bed of marl.
b. Sandy shales.
c. Thick-bedded but cross-grained sandstone.
d. Stains showing how the water comes out at base of marl bed.
e. Part of tip heap, blocks of sandy shale.

These are fine-grained, micaceous, red, and often flaggy at the top, and grey at the base. The topmost beds are only seen in Mr. Willcox's south quarry. In the lower series no large beds of shale are present. Plant remains occur practically throughout; if in the red stone, they bleach it to a grey, or more often yellow colour. By this characteristic I have been able to detect similar plant remains in the sandstone surrounding the Droitwich basin at Bellbroughton, Northfield, and the Tack Quarry at Hewell, as well as at the localities recorded by Murchison and Strickland. The sandstones often contain pebbles of marl, some of which, on fracture, occasionally show beautiful crystals of calcite, which also occurs commonly within the plant stems. Another curious mineral is green copper carbonate, which I have found both in the stems and as impregnations in the sandstone. These occurrences are comparable with that of the copper ores of Alderley Edge in Cheshire,[1] and possibly of Mansfeld[2] in the Hartz. At

[1] E. Hull: op. cit., pp. 54, 65, and 74.
[2] J. A. Phillips: "Ore Deposits," p. 28; London, 1884.

certain horizons the plants are found in well-marked carbonaceous layers. In some places in the sandstone are quite gigantic stems, one, for instance, being about 7 inches across and several feet long. I believe that the marl conglomerate, which usually contains fragments of bone, represents a definite horizon in all four quarries, but I have failed to locate its position in Mr. Griffin's north quarry, although it occurs there. If so, this is the only constant bed. It is curious that at Warwick most of the bones came from a very similar marly conglomerate; at Pendock, Symonds calls the fossiliferous bed an osseous conglomerate; and at Shrewley, Brodie mentions a conglomerate which also contains fish and Labyrinthodont remains. Small ripple-marks have been found in the sandstone in Mr. Willcox's north quarry. The false bedding points towards rapid sedimentation, and this is supported by the fact that leaves of *Zamites*, 6 inches long, have been found lying at right angles to the general direction of the bedding, and also doubled on themselves with a good thickness of matrix between the two parts. The sandstones, especially in their upper part, are intercalated with shale beds, and the following sections along the dip faces in two quarries 150 yards apart show the inconstancy of the beds very typically. (Fig. 2.)

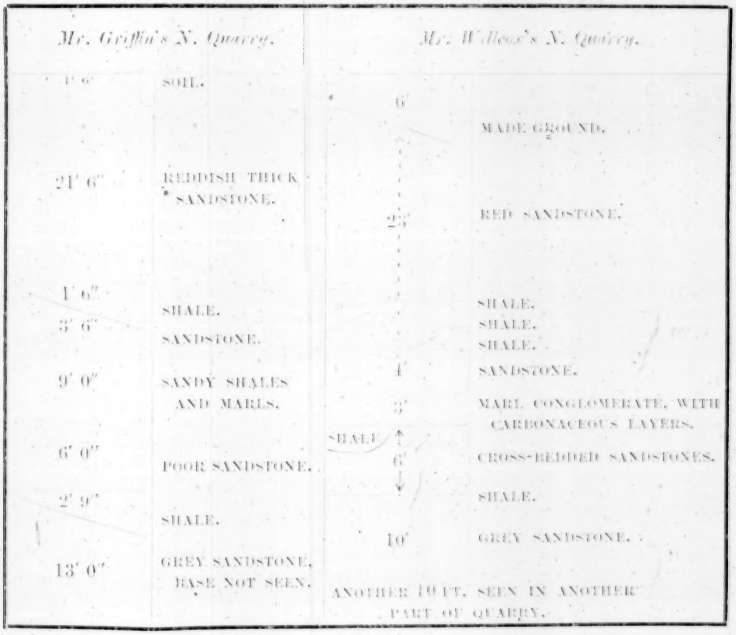


FIG. 2.

The sandstones are for the most part quite different in texture, and especially in bedding, from those of the Upper Keuper which I have, so far, seen at Inkberrow, Shrewley, and Leicester.

The shales, which occur really as flat-topped lenticles (see Fig. 1, *a*, *b*), are of various hues from brown to green. The majority are sandy,

but some are true marls, and break up into very fine fragments by rudely spheroidal weathering. The brown shales are well seen in Mr. Griffin's north quarry, where the 9 foot bed shown in the section has yielded good fossils, especially leaves of *Zamites*, which occur usually where the sediment changes from the sandy to the marly facies. These shales also show the same evidence of quick or even torrential sedimentation. The green ones are mostly sandy, and are best seen at the base of Mr. Griffin's south quarry, where they contain patches, absolutely black with vegetable matter, and quite free from sand. These sandy green shales are often minutely rippled, and apart from the black patches contain many fragments of plants and ? Arachnida. In Mr. Willcox's south quarry there are some red shales which have so far proved barren.

As regards the fossils, the most characteristic feature is the abundance of plants and Arachnidan remains. The latter are fragmentary. Murchison and Strickland[1] recorded from the Lower Keuper of Worcestershire—

Echinostachys oblongus, Brongn.
Part of a flabelliform palm-leaf.
Broad leaf of some Monocotyledonous plant.
Many narrow Monocotyledonous leaves resembling grasses.
Moulds of stems of doubtful character.

Mr. E. A. Newell Arber, who has very kindly assisted me by determining the plants, has examined their specimen of *Echinostachys* preserved at the Museum of the Geological Society, and regards it as a male cone of *Voltzia*. These were the only plants known from this horizon.

The following is a list of the fossils I have found, divided into those preserved in—

(i) *The Sandstone.*

PLANTÆ.
Equisetites arenaceus (Jaeger): pith-casts and leaves.
Zamites Vogesiacus (Schimper & Mougeot): leaves.
Voltzia sp.: external surface of stem, male cone, and pith-casts of stems.
Coniferous wood.
PISCES.
Spine of *Acrodus*.
Coprolite.
AMPHIBIA.
Teeth[2]: cranial, vertebral, and other bones of a Labyrinthodon (*Mastodonsaurus*)?
REPTILIA.
Hyperodapedon Gordoni.[3]

(ii) *The Shales.*

PLANTÆ.
Equisetites arenaceus (Jaeger): pith-casts.
Equisetites sp.
? *Chiropteris digitata*, Brongn.
? *Pterophyllum* sp.
Zamites Vogesiacus (Schimper & Mougeot): leaves.
Voltzia sp.: pith-casts of stem and male cones.
Conites sp.
ARTHROPODA.
Estheria minuta.
Many fragments of ? Arachnida.[4]
PISCES.
Diplacanthus cyphus.
Scales.

[1] Op. cit., p. 340.
[2] One of these is broken and shows very distinctly with a lens the characteristic structure.
[3] Part of the palato-maxillary bone, with three rows of teeth.
[4] I have shown some of these to Dr. Bather, who thinks that they may probably be referred to the Arachnida.

It will be seen from the above list that the fossils of the sandstone and of the shales are rather distinct, and that the fauna of the former recalls the vertebrates found at Warwick. The Labyrinthodont remains, next to the plants, are the most abundant fossils, but are apparently confined to the marl conglomerate.

The shale fossils, on the other hand, are better preserved, and show a great predominance of vegetable remains, but, in places, fragments of Arthropods are abundant. This is especially so in the above-mentioned black patches.

Of the Arthropods, the *Estheriæ* are very small, and quite different from the Upper Keuper type, so abundant at Shrewley. They resemble much more closely those that occur in the Rhætic, but I have not been able to determine whether they agree with the variety called *Brodiana*.[1] There is but one record of *Estheria* from the Lower Keuper of England, viz. at Alderley Edge.[2]

I have, so far, been able to find nothing comparable at all with the other Arthropod remains. There are pieces which are certainly segments of a jointed abdomen, and others which may represent carapaces. Dr. Bather thinks that some of the fragments may have belonged to a Scorpion, and some have a Merostomatous appearance.

Dr. Smith Woodward has kindly examined the only nearly perfect fish found, and refers it to *Dipteronotus cyphus*, Egerton, which has only once before been described, and that from near Bromsgrove.[3]

As regards the plants, the leaves of *Zamites Vogesiacus* are the most characteristic fossils. They are very abundant in the 9 foot shale bed in Mr. Griffin's north quarry. They are broad and lanceolate, with parallel nervation, average some 18 inches or more in length, and show the apex, and the base which has a well-marked callosity.

The pith-casts of *Equisetites* are abundant in the sandstone, but are fragmentary. There is a marked paucity of specimens showing the external surface and leaves.

The male cones of *Voltzia* are especially well preserved. Some show the complete cone with a basal stalk, both the external surface and also the internal structure being displayed.

It is because the Keuper plants hitherto described from England are so poorly preserved, and hence so dubiously identified, that the occurrence of even these few species at Bromsgrove in good preservation and some abundance is of especial interest. The abundance of Cycads and Equisetites points to a flora markedly Mesozoic, while the whole assemblage of fossils is that of the Lettenkohl (Lower Keuper) of South Germany, although some of the plants recall those of the Bunter of the Vosges,[4] while other species range up into the Schilfsandstein (Middle Keuper).

I have good hopes of adding to the above list by continuing my visits to these quarries, and by working out more completely the material recently accumulated; but since particular attention has of

[1] R. Jones, "Fossil Estheria": Pal. Soc., 1862.

[2] Rep. Brit. Assoc., 1905, where also compare the description of 'Vleys' with the marl beds of Bromsgrove.

[3] P. Egerton: Q.J.G.S., vol. x (1854), p. 367.

[4] Schimper & Mougeot: "Plantes fossiles du Grès bigarré," 1840.

late been drawn to the Trias by a committee of the British Association, this preliminary sketch of the results already obtained may be of some service.

My thanks are due to many friends, but especially to the quarry owners for very active help, to Mr. Arber for the identification of Triassic plants of which very little is known in this country, and to Dr. Smith Woodward for examining the vertebrate remains.

IX.—Notes on some Recent Work on the Bokkeveld Fossils.

By F. R. Cowper Reed, M.A., F.G.S.

IN a recent important article in the "Records of the Albany Museum, South Africa," vol. i, No. vi (1906), pp. 347–404, pls. vi–x, Professor Schwarz describes some interesting fresh material from the Bokkeveld Beds, and is able to add several new species to the steadily growing list. Incidentally he is led to criticise some previous work done by me on the Brachiopoda and Mollusca from the same beds. Whilst I welcome the new light he is able to throw on several of the obscure fossils with which I had to deal, I must demur to some of his conclusions, especially in the case of the Brachiopoda; and accordingly, as my opinion on his paper has been specially asked by other workers on this fauna, a few remarks appear to be requisite. It must not be forgotten that the specimens in all cases are poor and unsatisfactory, but Professor Schwarz has had the advantage over me of more abundant material.

1. With regard to his new species *Rensselaria relicta* (op. cit., p. 364, pl. vii, fig. 7), it is considered by Professor Schwarz to be perhaps identical with my *Rensselaria* sp. *a* (Ann. S. Afr. Mus., vol. iv, pt. 3, p. 176, pl. xxi, fig. 8). Without seeing his type it is naturally impossible for me to form a definite opinion, but his view seems to possess much probability, though my doubts as to the generic position of this shell have been recently expressed in my description of *Scaphiocælia* (?) *africana* (Geol. Mag., Dec. V, Vol. III (1906), p. 508). Better material will probably remove the existing uncertainty as to its specific and generic relations.

2. The ribbing in *Rensselaria hottentot*, Schwarz (op. cit., p. 365, pl. vii, fig. 8), as described and figured, does not suggest the genus *Rensselaria*, but rather the genus *Rhynchospira*, and the same remark applies to his *Trigeria simplex* (pl. vii, fig. 9), which I cannot agree is probably identical with my *Trigeria* aff. *Gaudryi*; the central grooved narrow fold or wide rib on the brachial valve, represented in Professor Schwarz's figures and mentioned in his descriptions, seems to forbid their reference to *Rensselaria* or *Trigeria*; and, as he remarks, *T. simplex* may rather be compared with Hartt's *Retzia jamesiana*. In placing the latter in the genus *Rhynchospira* I am merely adopting Clarke's view in the case of the Para examples, for the species has also been referred to *Notothyris* and *Centronella*.

3. Professor Schwarz arrives at somewhat different conclusions with regard to the specific separation of the members of the genus *Spirifer*, but he acknowledges the difficulties with which one has to

contend owing to the fossils occurring only as casts or impressions, and frequently in an imperfect condition. In the first place it cannot be denied that all the species described from these beds are closely allied, and that many intermediate forms occur which might be referred to one or other of the species with equal justice. Only the most marked forms at the extremity of each series of variations are in reality capable of precise definition, and it is by them that the specific characters have been established. Therefore the reference of many of the transitional examples and debatable specimens depends largely on the personal equation. In my case it should be remembered that I had the advantage over Professor Schwarz of examining the type-specimens in London. Professor Schwarz would restrict the name *Sp. Orbigugi*, Morris & Sharpe, to those forms possessing a more semicircular shape and a less incurved beak and more backward sloping hinge-area on the pedicle valve than *Sp. antareticus*, Morris & Sharpe. To the transversely fusiform shells with nearly a vertical hinge-area and rather strongly incurved beak in the pedicle valve, which I included under the name *Sp Orbigugi*, Professor Schwarz applies the name *antareticus*, Morris & Sharpe. In spite of the differences pointed out, and in view of further specimens which I have seen, I am reluctant to adopt his view, for the characters on which he relies do not seem to be constant.

My *Sp.* cf. *pedroanus* Professor Schwarz would include in his *Sp. antareticus* (= *Sp. Orbigugi*, mihi), but with this view I cannot completely concur, for there appear to be special features in the number, character, and relative size of the ribs which I have previously mentioned (Ann. S. Afr. Mus., loc. cit., p. 183, pl. xxii, fig. 5). Professor Schwarz also misunderstands my description by thinking that I took *Sp. pedroanus* to have only 10–16 ribs in all, but the fact that I largely rely for the comparison on the number of the ribs (20–22) in the South African form should have been sufficient to indicate that I had clearly in my mind Hartt's statement that there were 10–16 ribs *on each side* of the fold and sinus. I am, however, ready to admit that my *Sp.* cf. *pedroanus* may not be identical with the South American species bearing this name, and may be only an extreme variety of the *Sp. antareticus* of Professor Schwarz.

In the case of *Sp. Ceres*, mihi, Professor Schwarz believes that one of the specimens figured by me (pl. xxii, fig. 6) is an overgrown example of *Sp. Orbigugi* or *Sp. antareticus*, though his very reasons for adopting this view considerably weaken his arguments in favour of the separation of *Sp. Orbigugi* from *Sp. antareticus*. Likewise his inclination to identify *Sp. Ceres* with *Sp. Hawkinsi* (for which I cannot see sufficient evidence) proves that he allows much latitude of variation in his specific interpretations.

It is always a misfortune to have to multiply specific names, particularly in connection with poorly preserved fossils, and one would be glad to reduce the number of species of *Spirifer* recorded from the Bokkeveld Beds. But when local varieties or zonal mutations may be suspected it is wise not to neglect minor differences observable in specimens from other localities and rocks than the type; and particularly does this seem to be

a necessary warning in the case of the Bokkeveld Beds with their diverse lithological development, and in view of the absence of minute zonal work or zonal collecting from the beds included in this stratigraphical series.

4. In the case of the Mollusca Professor Schwarz is able to record several new species. Perhaps with regard to the specimen identified as *Cypricardella Pohli*, Clarke, the figure leaves something to be desired, as, comparing it with the one given by Clarke of this species, there does not seem to be much resemblance. However, without seeing the specimen a fair criticism cannot be passed.

5. With regard to the trilobites and the points of difference between Professor Schwarz and Mr. Lake in their identification, it is not for me to pass any opinion. A small collection recently presented by the South African Museum to Cambridge includes a good example of the new species *Homalonotus hippocampus*, Schwarz, which, as the author states, is sharply separable from *H. Herscheli*. I notice the subgeneric name *Cryphaeus* still used by Prof. Schwarz in connection with *Phacops*, though it has been shown to be preoccupied (Geol. Mag., Dec. V, Vol. II, 1905, p. 173), and it is doubtful if any of the South African forms referred to this subgeneric group, *Asteropyge*, can be rightly retained in it without undue extension of its meaning.

In a subsequent article a review of the whole fauna will be given.

NOTICES OF MEMOIRS.

I.—A Contribution to our Knowledge of the Limestone Knolls of Craven. By A. Wilmore, F.G.S.[1]

THE Craven Lowlands district, between the great faults on the north-east and the grit hills of the Pendle Range on the south, is characterised by a well-known series of limestone knolls which have been the subject of much discussion.[2] Having worked in the district for some years I venture to make the following suggestions.

1. The words 'knoll' and 'reef-knoll' seem to be differently understood by different workers. It seems to me desirable to drop the term 'reef-knoll.' This term was applied by Mr. Tiddeman to certain extreme members of a series: there is every possible gradation between these and ordinary rounded knolls to which the term would never be applied. Further, the hills so named by Mr. Tiddeman have not all originated in the same way.

[1] Paper read in Section C (Geology) at British Association Meeting, York, 1906.

[2] Tiddeman: Brit. Assoc. Rep., 1899; Brit. Assoc. Handbook for Leeds and Airedale, 1890; Brit. Assoc. Rep., 1900; Geol. Mag., January, 1901. Marr: Q.J.G.S., vol. lv, pt. 3 (August, 1899); also Dakyns in same number. W. Hind & Howe, "On the Pendleside Group at Pendle Hill, etc.": Q.J.G.S., vol. lvii, pt. 3 (August, 1901). Sir A. Geikie: "Text Book," vol. ii (1903), p. 1041.

II. The following types of knolls may be recognised:—

(A) Those in the grey or bluish-white limestone. Some of these are well-bedded and very fossiliferous; some are obscurely bedded; some are not *apparently* very fossiliferous.

(B) Those in the dark limestones with numerous shales: these knolls are lower and more rounded.

(C) Scar-knolls; truncated folds weathered into semi-rounded and more or less detached masses. These vary from small crags through large peninsular masses to long scar-like ridges. These may be in the white or dark limestones. Sometimes a scar-knoll has been detached from the main mass of a limestone by weathering.

There are gradations of every degree connecting these types.

III. Examples of all these types of knolls occur on one well-defined horizon. They may all be seen striking parallel with the Pendleside shales containing *Posidonomya Becheri*, *Posidoniella laevis*, *Aviculopecten papyraceus*, and immediately succeeded by these shales. The succession may be seen at Cracoe and Thorpe, Stockdale, Newsholme, Broughton and Thornton, Downham, Slaidburn.

IV. The knolls are most conspicuous on the margins of the district. They are seen close to the faults at Threshfield, Malham, Attermire, Stockdale, and Bell Busk. Against the grit ridges on the southern side they are well developed at Thorpe and Cracoe, Broughton and Thornton, and near Downham.

It is noteworthy that knoll-like masses are seen *north* of the Grassington branch of the Craven faults, at Craven Moor, and near Dibble's Bridge. Here the massive white limestones come up with a much greater dip than is usual north of the faults.

The whole district is much folded. There are well-defined folds with N.E.-S.W. axes intersected by less conspicuous folds parallel to the main Pennine axis. The interference of these fold-systems seems to have directly produced some of the knolls. Folding is seen everywhere, in both the dark and the white limestones; though the well-bedded dark limestones naturally show it best. Minor faults are common, and some of the knolls appear to be due in part to faulting.

V. The more massive knolls of white limestone appear to be due to irregular aggregations of submarine débris. Folding has ridged up these massive limestones, and weathering has intensified the difference between these and the commoner knolls of the district. The smaller knolls are due to folding (as in IV) and subsequent weathering.

II. — Investigation of the Fossiliferous Drift Deposits at Kirmington, Lincolnshire, and at various localities in the East Riding of Yorkshire.[1] By J. W. Stather, F.G.S.[2]

The Speeton Shell-bed.—As mentioned in last year's report, this fossiliferous estuarine sand was first described by Professor Phillips

[1] Report of the Committee, consisting of Mr. G. W. Lamplugh (Chairman), Mr. J. W. Stather (Secretary), Dr. Tempest Anderson, Professor J. W. Carr, Rev. W. Lower Carter, Mr. A. R. Dwerryhouse, Mr. F. W. Harmer, Mr. J. H. Howarth, Rev. W. Johnson, Professor P. F. Kendall, Mr. H. B. Muff, Mr. E. T. Newton, Mr. Clement Reid, and Mr. Thomas Sheppard.

[2] Paper read in Section C (Geology) at British Association Meeting, York, 1906.

in his "Geology of Yorkshire" (pt. i, p. 100), and later by Mr. G. W. Lamplugh in the GEOLOGICAL MAGAZINE for 1881 (p. 176). As the bed is almost always obscured by slips, so that its relations to the drift are open to question, it was decided to examine its position by excavations.

Since the presentation of the last report several excavations have been made in the neighbourhood of the exposures seen by Professor Phillips and Mr. Lamplugh, and your Committee reports that, though the results obtained are corroborative of the accounts given by the observers above named, they also include certain new points of interest.

The largest excavation was made in the ridge between Middle Cliff and New Closes Cliff at Specton, and at this place beds were exposed as follows:—

			ft.	in.
	(A)	Boulder-clay (lower part only excavated)	45	0
Estuarine Shell-bed.	(B)	Fine chalky gravel	1	6
	(C)	Yellowish sandy silt with shells	6	2
	(D)	Black silt	4	0
	(E)	Black silt with sandy streaks and a little gravel ...	2	0
	(F)	Fine gravel, chiefly of chalk	4	0
	(G)	Specton Clay (base of *Bel. jaculum* zone 1½ feet, and "compound nodular band" 6 inches, forming the upper portion of the sloping cliff of secondary clays 84 feet above beach-level).		

It will be seen from the above section that the shell-bed is here 17 feet 8 inches thick, and its base is about 86 feet above the present beach.

The gravel (F) rests on the *Bel. jaculum* clays, but contains some material washed from the lower beds of the Specton Clay, such as fragments of *Bel. lateralis*, etc.

The excavation showed that the beds do not rest on a flat surface of Specton Clay, but that their surface dips into the cliff at an angle of 25 degrees, and that the bedding of the shelly deposit itself also dips into the cliff at about the same angle.

Shells occur throughout the silty beds, but are most plentiful in bed C. When excavating, the shells seen were *Cardium edule*, *Tellina balthica*, *Scrobicularia piperata*, and *Hydrobia*. A quantity of the shelly material was collected for washing, on which the Committee will report later.

Search was made for the shell-bed at the same level both north and south of the main excavation. Southwards no trace was observable, but northwards the beds were traced fifty yards along the slopes of New Closes Cliff.

At the foot of the cliff, about 500 yards northward of the site of the excavations, similar shelly silts were laid bare during favourable conditions of the foreshore early this year. In this exposure the beds attained a thickness of 4 to 5 feet, and were traceable for at least 100 yards. The silts rested on Kimeridge Clay, and were overlain by glacial drifts, which at this locality are extremely thick.

At the north end of this section the following particulars were noted:—

	ft.	in.
Boulder-clay with interealated stratified sand and gravel, not less than	120	0
Fine chalky gravel	2	0
Silt with shells	3	0
Kimeridge Clay	4	0

The thanks of the Committee are due to the Right Hon. the Earl of Londesborough for permission to investigate the shell-bed at Specton, and to Mr. C. G. Danford, of Reighton, for help in many ways.

REVIEWS.

I.—Memoirs of the Geological Survey, England and Wales. Explanation of Sheet 110: The Geology of the Country around Macclesfield, Congleton, Crewe, and Middlewich. By T. I. Pocock, M.A. With Contributions by G. Barrow, F.G.S., W. Gibson, B.Sc., F.G.S., C. B. Wedd, B.A., F.G.S., and J. A. Howe, B.Sc., F.G.S.; and Notes on Fossils by E. T. Newton, F.R.S.[1] pp. 138. 1906. Price 2*s.* 6*d.*

Map. Sheet 110. 1 inch to the mile. An edition showing drift and solid. Printed in colours. Price 1*s.* 6*d.*

IN this new issue of Sheet 110 we have an excellent map at a low cost. The new method, adopted in the map of Stoke-on-Trent, immediately contiguous, supersedes the old hand-coloured maps, with their inaccuracies due to the personal vagaries of the colourist, the difficulty of getting the same tint of colour on different copies, and the want of permanence in the colour, due to fading, and to the fact that the colours run, if the map gets damp. The production of the map is one for hearty congratulations to all concerned, but we would fain have seen two editions, a drift and a solid.

The present edition attempts to show both, consequently the solid geology of the area is not as distinct as it might be. The sheet introduces more country to the west and less of the east than in the old edition, and on the whole takes in a much larger area. We are glad to see the term Pendleside Series adopted for the beds between the Carboniferous Limestone and the Millstone Grits, and a distinctive colour adopted for them. We hope that the Survey will continue the use of the term for similar beds on the eastern side of the Pennine uplift and thus avoid further ambiguity.

The map, we understand, is printed and coloured at the Ordnance Office, published by the Board of Agriculture, and distributed, as agent apparently, by Fisher Unwin.

The Memoir contains detailed descriptions of the various divisions of sedimentary rocks which occupy the area of the map. They include

[1] A brief note of this Memoir appeared under "Notices of Memoirs" in the December Number of the Geological Magazine, 1906, p. 558.

the small inlier of Carboniferous Limestone of Astbury with its volcanic tuff, an extensive development of the Pendleside Series and Millstone Grits, and the Coal measures of the Biddulph Basin. East of the Red rock fault the whole area is occupied by Triassic rocks of the Bunter and Keuper divisions. The whole district is more or less overlain by glacial deposits, but the high ground on the eastern margin of the map is comparatively free from drift.

In the last edition of the Memoir on this area there was a small sketch-map of the district geologically coloured. The absence of this we regret in the new edition; we should like to see such a map in every memoir issued by the Survey. It is most useful for reference by the student of the memoir. All work in the area by local geologists has been duly acknowledged, and we note that the palæontology is almost entirely due to local workers.

The area is an interesting one, and includes the western limb of the great Pennine anticlinal, and part of the Triassic plain which abuts against it. In the north-west corner of the map the surface of the land is 84 feet above O.D., while at Shutlingslow the top of the hill is 1,658 feet above O.D.

In the area included in the map the Millstone Grits are thinning out rapidly from north to south and from east to west. In the north-east five beds of Grit can be made out, but at Mow Cop only two of them, supposed to represent the first Grit or Rough rock and the third or Roaches Grit, are found, and these much less thickly bedded than to the north-east.

The area contains a very interesting patch of igneous rock well exposed in Astbury Old Limestone Quarry and the stream to the north. The north end of the quarry shows a large thick mass of agglomerate containing well-preserved fossils and blocks of marmorised limestone. In the southern part of the quarry beds of intrusive material, which have baked the shales above and below them, are to be seen intercalated in a shale and limestone series which forms the base of the Pendleside Series, and contain *Prolecanites compressus* and Trilobites and Corals belonging to *Amplexizaphrentis* and *Cyathaxonia*. We fail to find any account of this important fauna in the memoir.

The chapter on the Pendleside Series is of interest, and we congratulate the author that he has wisely seen fit to include a large amount of palæontology in this part of his memoir.

Eighteen pages are devoted to the Millstone Grit, and here, alas! we find no palæontological work, though the shales between the grits contain marine faunas. Twelve pages only are allowed for a description of the Coal measures, and two-thirds of a page is all we have on fossils and fossiliferous horizons in that field. In the chapter on the Trias (p. 59) we meet with the following statement: "The district, however, affords evidence that this continental period (alluding to the Trias as 'this remarkable land period') slowly passed away, and was succeeded by one of regional depression, during which the Midlands and a large portion of England sank once more beneath the ocean." Taken in conjunction with this we find on p. 65: "The Jurassic deposits, which elsewhere conformably succeed the Trias, doubtless overspread the lower, if not the higher, parts of this area

also; a large outlier still remains in the county of Shropshire. Nor is it likely that the north-western counties escaped the more general submergence of England which ensued in Cretaceous times." We take exception to these views and ask for the proofs or evidence.

Granted the continental conditions, or rather the inland salt sea, of Trias times, out of which the Lake Hills and the Higher Pennines above 800 feet appeared, what evidence is there that these areas were ever again submerged? The crevices and caverns of the Carboniferous Limestone contain no relics of Jurassic or Cretaceous age, as is the case in Somersetshire. No outliers of Secondary rocks are found in the Pennine area or the north-west counties of England, or occur nearly as high above sea-level as the highest Triassic beds of the Midlands. The large sand and clay pits of Staffordshire and Derbyshire contain nothing later than Triassic material and Glacial drift. One cavern in Derbyshire alone has yielded bones of Pliocene animals, but this fact does not bear on the question of a depression beneath the sea to over 2,000 feet in the Midlands. Consider the height above O.D. at which Jurassic deposits are found elsewhere, even the two nearest to the area, the Shropshire and Needwood forest outliers. They are both at a much lower level even than the highest Triassic beds. In connection with this subject it would have been of importance and interest if the authors of the memoir had discussed the limits above O.D. of the Trias of the district. There is a long and important section on Glacial and other superficial deposits. The area is classical and contains the highest bed of marine shells in England, 1,200 feet above sea-level.

The Memoir is a useful introduction to the geology of the area; the illustration and sections are helpful to the geological student, and give him a graphic view of the tectonic structure of the district.

W. H.

II.—Summary of Progress of the Geological Survey of the United Kingdom for 1905. pp. 209, with 4 plates and 3 text-illustrations. Price 1*s*.

THIS is somewhat late in issue, considering that the far more elaborate Report of the Transvaal Geological Survey for the same year reached us some weeks ago. The present work contains particulars of the field-work in Derbyshire and Nottinghamshire, in Cornwall, Carmarthenshire, and Pembrokeshire, in the North and West Highlands of Scotland, and around Glasgow and Airdrie. The Survey of Ireland was severed from that of Great Britain during the early part of the year, so there has not been much to record about it. Among notable contributions to this work are Mr. J. A. Howe's report on Road-stones; Dr. Flett's descriptions of Lewisian rocks; Mr. Barron's account of recent excavations in London; and Mr. H. A. Allen's Catalogue of Types and Figured Specimens of British Lamellibranchiata from the Oolites, preserved in the Museum of Practical Geology.

III.—E. W. Berry. I.—A Brief Sketch of Fossil Plants. II.—The Flora of the Cliffwood Clays. Annual Report, Geological Survey, New Jersey, for 1905, part ii, pp. 99–156, with 8 plates and 7 text-figures. Trenton, N.J., 1906.

IN this sketch of fossil plants Mr. Berry touches very briefly upon a number of points connected with the study of palæobotany, such as methods of preservation, early views regarding fossils, and leaf venation. Perhaps the most interesting sections are those devoted to generalized ancestral forms and the Recapitulation Theory. Mr. Berry speaks of certain mid Cretaceous fossils, such as those referred to the genus *Sassafras*, known only as leaf-impressions, as being synthetic types, combining characters common to other genera. We agree with the author's remark that "it is hardly safe to draw too definite conclusions from the evidence of one set of organs, such as leaves." As illustrations of the truth of the Recapitulation Theory, which Mr. Berry applies in a whole-hearted manner to the Angiospermous leaf-impressions, fossils assigned to *Liriodendron* and *Myrica* are discussed, and the leaves of the earliest representatives of these genera are found to resemble the 'juvenile' foliage of seedlings of the living plant.

In this connection we may repeat a word of warning. It may be taken as a general rule, to which the exceptions are but few, that it is not safe, we might almost say not scientific, to refer a fossil Angiospermous plant to a living genus solely on the evidence of leaf-impressions; an axiom which is too often lost sight of by those who devote attention to the difficult study of such plant remains.

This bright and interesting sketch concludes with a brief review of the succession of geological floras, especially in the United States. Some of the statements made are now hardly accepted, as, for instance, the proof of the occurrence of "ferns (Filicales) and horsetail rushes (Equisetales)" in the Cambrian and Silurian rocks, the Dawsonian theory that the Hydropteridæ were vastly abundant in the Devonian period, which the author refers to in a guarded manner, and the view, now no longer tenable though current as recently as the publication of this sketch, that the Carboniferous and Permian Fern-like plants were largely referable to the family Marattiaceæ. The interesting diagram included to illustrate the distribution of plants in geological time, and what is known as to their phylogeny, leaves one with the impression that the author holds that, in many cases, plant life was more varied and abundant at the *end* of a geological period than at the *beginning*, a theory which it would be exceedingly difficult to prove.

The second paper contains a description of the Cretaceous flora of the Cliffwood Clays of New Jersey. The most interesting specimen figured is a new Fern-like plant, apparently in the fertile state, for which the new genus and species *Heterofilicites anceps* is proposed, but there appears to be some doubt as to whether the sporangia-like bodies are really fructifications.

Among the other leaf-impressions described and figured are new species referred to *Picea*, *Platanus*, *Liriodendron*, and *Sterculia*.

E. A. N. A.

IV.—A New Geological Map of Ireland.

MESSRS. J. BARTHOLOMEW & CO. have just published a "Map showing the Surface Geology of Ireland, reduced chiefly from the Ordnance and Geological Surveys under the direction of Sir Archibald Geikie, D.Sc., LL.D., F.R.S., late Director-General of the Geological Survey." Scale, 10 miles to 1 inch. Price 6*s*.

The map is on the same scale as Sir A. Geikie's maps of England and Wales and Scotland, issued by the same publishers, and is executed with even greater attention to detail; in fact, where the covering of drift is absent, the amount of detail shown is wonderful. At the same time, from the point of view of those who are neither agriculturists nor glacialists, it is a great pity that the map has not been issued as a solid-geology map, like its English and Scotch companion maps. The explanation is as follows:—The map was printed at the suggestion of the Department of Agriculture for Ireland, whose original intention was to have two maps, one showing solid geology and the other drift geology. Subsequently, however, they decided to have only one map, and chose the drift map as best suited to their requirements. It is to be hoped that Sir A. Geikie and Messrs. Bartholomew may see their way to issuing, at the earliest possible date, a solid-geology map, as the geological structure of the country is very much obscured by the drift, although it should be mentioned that the boundaries of the underlying formations beneath the drift are given. To make them out, however, requires minute study, so that a far better general idea of the structure of the drift-covered country is obtainable from Professor Hull's map, in spite of its less detailed character.

B. Hobson.

V.—The Bernese Oberland.

Das Berneroberland und Nachbargebiete: ein geologischer Führer, von A. Baltzer. Mit 74 Figuren im Text, und einem Routenkärtchen. Sm. 8vo; pp. 348. Berlin: Gebrüder Borntraeger, 1906.

THIS little work is one (No. xi) of a series of illustrated geological guidebooks to various districts in Europe. They have all been prepared by thoroughly qualified writers, among whom are to be found such well-known names as those of E. W. Benecke and A. Tornquist.

The volume before us is devoted to that beautiful and much frequented part of Switzerland known as the Bernese Oberland, which will conjure up for many a reader the most delightful recollections of long rambles among its mountains and valleys. It is divided into a number of routes and branch routes, and under each of these the physical and geological features are described with as much detail as the limits of space will permit. Some of the illustrations are in outline, others are reproductions from photographs, the latter mostly provided with key-plates, the different classes of rocks being indicated by the usual methods. There are also two plates, slightly tinted, from drawings made by the author to illustrate the Aletsch laccolith.

The writer, mindful that his little book is to serve as a guide, gives careful directions from place to place, adding the distance to be traversed on each journey that the wayfarer may know what is before him. There is a small map at the beginning of the book (scale 1 : 1,000,000) marked with red and blue lines, indicating the main routes and their branches described in the text. Its area extends approximately from Basel (the starting point for all the tours) in the north-west corner of the map to Leuk in the south-west, and from Winterthur in the north-east to Airolo in the south-east.

A. H. F.

VI.—Geological Survey of Western Australia. Bulletin No. 23: Third Report on the Geological Features and Mineral Resources of the Pilbara Goldfield. By A. Gibb Maitland, Government Geologist. 8vo; pp. 92, with 7 geological maps and 13 figures. (Perth, W.A., 1906.)

THIS report contains descriptions of those mining centres in the Pilbara Goldfield not referred to in Bulletins 15 and 20. It includes full details of the gold-mining centres of Tambourah, Western Shaw, North Shaw, and Just-in-time, together with the tin-fields of Wodgina and Cooglegong. It is fully illustrated with coloured geological and mining maps, which help greatly in elucidating the text. A general summary is also given of the geological features, mineral resources, and future prospects of the Pilbara Goldfield, drawn up by Mr. A. Gibb Maitland, mostly from personal investigations. The author was assisted in the field-work by Mr. H. W. B. Talbot.

The occurrence of sections reveals geological structures not met with in the more southerly districts, and these also throw much light upon problems connected with the geology of other goldfields.

The following table exhibits the succession of the rocks met with in the Pilbara Goldfield:—

Recent	Blown sand, alluvium of the river beds, and residual deposits.
Oakover Beds (age?) ...	Sandstones, limestones, etc.
Nullagine Beds (age?) ...	Sandstones, grits, conglomerates, and volcanic rocks. (Gold-bearing in places.)
Mosquito Creek Beds (age?) ...	Grits, shales, and fine conglomerates. (Gold-bearing in places.)
Warrawoona Beds (Archæan?)	Metamorphic sedimentary rocks, quartzites, conglomerates, greenstone schists, and allied rocks. (Gold-bearing.)
Granite and gneiss	(Tin- and tantalite-bearing and auriferous in places.)
Dolerite, Diabase, and Gabbro Dykes.	

The granite and gneiss are almost everywhere intrusive into the oldest rocks of the district. It is in the granite that the tin veins, and also the richest quartz reefs, occur. The total yield of gold of the various mining centres up to the end of 1905 amounts to 109,464 oz., or an average of 1·71 oz. per ton of ore. As to the future prospects of mining in this district, Mr. Gibb Maitland is confident that, with

due regard to the prevailing geological conditions, it will continue to produce gold, tin, and tantalite, the capabilities of the field, despite its relatively long existence, being by no means exhausted.

A. H. F.

VII.—New York State Museum. John M. Clark, Director (N.Y. State Education Department). Bulletin 90, Palæontology 14: Cephalopoda of the Beekmantown [Calciferous] and Chazy Formations of the Champlain Basins. By Rudolf Ruedemann, Assistant Palæontologist. 8vo; pp. 393–528, plates 1–38. Albany, 1906.

THE Silurian region of the Lake Champlain basin has proved remarkably rich in fossil remains, which far exceed in abundance those collections made by Professor James Hall in his pioneer work during the progress of the Geological Survey of 1836–43, chiefly in the Adirondack region.

The attention of palæontologists was directed to the Lake Champlain basin by descriptions from the pen of R. P. Whitfield of the rich fauna derived from the Beekmantown formation at Fort Cassin, Vermont. This led to the investigation of the faunas on the New York side of the basin, of which Dr. Ruedemann's work (dealing exclusively with the Cephalopoda) is an important part.

The author makes use in his work of Hyatt's system in classifying his material, believing that it embodies a true expression of the natural relationship of the forms, so far as the Nautiloid Cephalopods are involved. The generic position of a considerable number of the species are, however, left undecided, being provisionally placed in the genus to which they appear to be most closely affiliated, the imperfection of some of the material at the author's disposal rendering such a course unavoidable.

After some remarks upon the Cephalopods described by E. Billings, from the Quebec Group of Newfoundland, Quebec, and Philipsburg, of which about 49 species were described, but very few figured, the author presents detailed sections of the Beekmantown and Chazy Beds. A description of the species follows, prefaced by a brief note upon the terminology employed, which is that of Hyatt, with some alterations and additions proposed by Holm and others.

The species are carefully and fully described, and well illustrated in the text and in the plates. *A propos* of the latter we are glad to see lithography brought into use, instead of the cheaper but much less satisfactory 'process' methods so often resorted to for illustrations.

Synoptic tables at the end of the specific descriptions show that out of 71 species 24 are regarded as new.

The work concludes with an interesting summary of the relations of the Cephalopod faunas of the Beekmantown and Chazy formations to those of other regions. A bibliography and index are also added.

A. H. F.

REPORTS AND PROCEEDINGS.

Geological Society of London.

1.—November 21st, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communications were read:—

1. "The Kimeridge Clay and Corallian Rocks of the Neighbourhood of Brill (Buckinghamshire)." By Arthur Morley Davies, A.R.C.S., B.Sc., F.G.S.

The paper contains two principal divisions:—

(1) An account of the section of Rid's Hill, Brill. At the summit are Lower Portlandian sands, not well exposed; below these comes a thickness of about 50 feet of Upper Kimeridge Clay, with only one small exposure of grey shale containing black lignite and a few fossils. At the foot of the hill, a large brickfield shows the following sequence:—

	Feet.
8. Grey, creamy-weathering clay (zone of *Exogyra virgula*)	4
7. Grey, creamy-weathering clays with crushed shells, darker and slightly selenitic towards the base ... ... about	17½
6, 5, & 4. Two bands of creamy limestone, with marly clay between (*Pictonia* cf. *Cymodoce*, *Pholadomya aequalis*)	4
3. Dark grey, brown-weathering clay, with occasional phosphatic nodules	8
2. Black shaly clay, weathering lilac-grey with yellow stains, highly selenitic (*Belemnites abbreviatus*, *B. nitidus*, *Ostrea deltoidea*, *Gryphaea dilatata*, *Trigonia Voltzii*, etc.)	14
1. Band of grey limestone (*Perisphinctes decipiens*, *Trigonia Judaïana*) at the base.	

There have also been dug up, probably from the selenitic clay (No. 2), doggers composed largely of *Serpula tetragona*, Sow., and *Arctica* (*Cyprina*) *cyreniformis* (?), Blake, yielding many other fossils, including *Cardioceras alternans* (von Buch) and *Belemnites nitidus*, Dollf. The possibility of the selenitic clay being Ampthill Clay is discussed, the conclusion being that only Lower Kimeridge Clay is exposed in this section.

(2) The rock of Studley and Arngrove, described by Phillips as an argillaceous chert, is shown to be mainly composed of the globate spicules of the tetractinellid sponge *Rhaxella*. It has a much more limited extension eastward than the geological map would suggest; but, on the other hand, it is found to form part of the outcrop of normal Corallian rocks from Waterperry by Stanton St. John to Holton Wood. Its exact relation to the Oxford Clay is described, and an increased list of fossils is recorded from it.

Palæontological notes are given on certain species of Lamellibranchia and Annelida, chiefly from the Lower Kimeridge Clay.

2. "On the Skull and greater portion of the Skeleton of *Goniopholis crassidens* from the Wealden Shales of Atherfield (Isle of Wight)." By Reginald Hooley, F.G.S.

In the late Autumn of 1904, at a place locally called 'Tie Pits,' near Atherfield Point, a huge mass of the cliff, comprising many thousand tons of the Wealden Shales, subsided, pushing its foot

across the beach until below low-water line. As the sea washed away the base, the mass continued to sink, and fresh horizons were denuded. In 1905 a series of heavy 'ground-seas' cast up blocks of limestone and ironstone, containing crocodile bones, which were discovered on the sand between high- and low-watermarks. The skull came ashore in six pieces. Fragments of bones and scutes were constantly picked up; and the author is indebted to Prof. T. McK. Hughes for the block which had been picked up and sent to the Sedgwick Museum at Cambridge. The specimens were derived from a horizon 80 to 90 feet below the top of the Wealden Shales. A history of the British Goniopholidæ from the foundation of the genus by Owen in 1841 is given, and it is noted that the frame in the Mantell Collection, now in the British Museum, not only contains the two type-blocks, but a smaller one with the impression of the orbital region of the skull, a fragment of the frontal bone, and the impression and fragments of a moiety of the right ramus. The skull and bones of the new specimen are next described, and a detailed comparison is instituted between *G. simus* and *G. crassidens*, with the result that the specimen is referred to the latter species, differing in several important particulars from the former. Comparisons are also made with other species of *Goniopholis*, with *Nannosuchus*, and *Oweniasuchus*. In conclusion, the author notes that, while in certain features the species come nearer to the Teleosaurs than *G. simus*, it is farther removed than the latter from them in the position of the posterior nares.

II. — December 5th, 1906. — Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communications were read:—

1. "On the Geological Conditions which have contributed to the Success of the Artesian Boring for Water at Lincoln." By Professor Edward Hull, M.A., LL.D., F.R.S., F.G.S.

This boring has its source of supply in strata which rise to the west, but to the east dip down towards the North Sea. There exists no information as to whether the eastern border of the water-bearing formation thins out against a concealed ridge of Palæozoic rocks. The water-yielding stratum is reddish, soft, porous sand-rock, reached at a depth of 1,561 feet and penetrated to a depth of 474 feet. About one million gallons of water rise to the surface daily. The sand-rock belongs to the New Red Sandstone, which crops out from York to Nottingham with a breadth of about eight miles. The hydraulic pressure at the bottom of the boring is that due to about 2,035 feet, and the friction of the water in percolating the rock accounts for the fact that the water can be pumped down during the day but rises again in the night. The formations penetrated are the following:—Alluvium and Lower Lias 641 feet, Rhætic beds 52 feet, Red Marl and Lower Keuper Sandstone 868 feet, Bunter Sandstone 454 feet. The quantity of water drawn from the New Red Sandstone, at and below the outcrop defined, amounts to not less than 20 million gallons.

and the total available quantity of water percolating into the sandstone amounts to about 500 millions.

2. "Notes on the Raised Beaches of Taltal (Northern Chile)." By Oswald Hardey Evans, F.G.S.

The town of Taltal is situated partly on the dry bed of a broad river and partly on a gently inclined plain that fringes the bays of the coastal ranges far to the northward, and runs up the valleys to a considerable altitude and distance from the coast. The material of this plain consists of sands and well-rounded gravel derived from the rocks of the adjacent hills, mingled with shells and some isolated boulders of considerable size. The formation is impregnated with salt, and there protrude through it curiously weathered remnants of former stacks and islets. The plain rises in terraces, the highest of which are somewhat obscure, and sometimes portions of these higher terraces are preserved in the stacks and islets. A second coastal shelf also occurs, marked by a line of shallow caverns, some excavated in igneous rocks. Some, at least, of the shell-accumulations associated with the plain contain pottery, and are associated with Indian kitchen-middens, but the beds of shells in the gravel, containing occasionally whale-bones, give satisfactory evidence of the marine origin of the terraces. Some of these shells are replaced by crystallized brine, and calcium sulphate occurs in some sections. Profound ravines (*quebradas*) occur in the massive rocks bordering the plain, although the climate is now so dry that rain-erosion is practically non-existent.

CORRESPONDENCE.

THICKNESS OF LAND-ICE.

Sir,—I have not followed the discussion to which Mr. Lamplugh alludes in his letter of November 7th, but I should be thankful to be allowed to make a remark upon the final sentence, where he says that "the evidence for the past and present existence of ice of greater thickness than 1,600 feet is so strong that physicists who wish to apply this limitation may be advised, in their own interest, to revise their calculations."

I published a paper "On the Thermal Conditions and Stratification of the Antarctic Ice" in the Phil. Mag. for June, 1879, in which I arrived at the conclusion that supposing the surface at zero Fahr., after the ice had accumulated to the thickness of 740 feet (about), it would begin to melt at the bottom owing to the pressure; but I concluded (p. 385) that "No certain limit can be imposed upon the thickness to which the ice might accumulate, provided the snowfall be more than sufficient to counterbalance the melting at the bottom."

I do not know who the physicists may be to whom reference is made in Mr. Lamplugh's letter, but as I have corresponded with Professor Schwarz upon this subject I have thought it as well to show that for one *my* calculations do not require revision.

O. Fisher.

Graveley, Huntingdon.
December 3rd, 1906.